

Practical Machine Learning Course Project

Siti Nurillah Binti Mohd Fadzil

January 29, 2016

Data

The training data for this project are available here:

<https://d396qusza40orc.cloudfront.net/predmachlearn/pml-training.csv>
(<https://d396qusza40orc.cloudfront.net/predmachlearn/pml-training.csv>)

The test data are available here:

<https://d396qusza40orc.cloudfront.net/predmachlearn/pml-testing.csv>
(<https://d396qusza40orc.cloudfront.net/predmachlearn/pml-testing.csv>)

Reading and Cleaning Data

Start with reading both training and testing instances.

```
library(data.table)
library(caret)
```

```
## Loading required package: lattice
## Loading required package: ggplot2
```

```
library(randomForest)
```

```
## randomForest 4.6-12
## Type rfNews() to see new features/changes/bug fixes.
```

```
library(foreach)
library(rpart)
library(rpart.plot)
library(corrplot)
library(ggplot2)
```

```
#read training data
training_data <- read.csv("./pml-training.csv", na.strings=c("#DIV/0!"," ", "", "NA", "NAs", "NULL"))
#read test data
testing_data <- read.csv("./pml-testing.csv", na.strings=c("#DIV/0!"," ", "", "NA", "NAs", "NULL"))
```

Columns with NAs will be removed. Besides that highly correlated variables and variables with 0 (or approx to 0) variance will be removed.

Cleaning data

```
clean_training <- training_data[, -which(names(training_data) %in% c("X", "user_name", "raw_timestamp_part_1", "raw_timestamp_part_2", "cvtd_timestamp", "new_window", "num_window"))]

#remove columns with NAs
clean_training = clean_training[, colSums(is.na(clean_training)) == 0]

#remove variables with 0 or near to 0 variance
zero_variance =nearZeroVar(clean_training[apply(clean_training, is.numeric)], saveMetrics=TRUE)
clean_training = clean_training[, zero_variance[, 'nzv'] == 0]

correlation_matrix <- cor(na.omit(clean_training[apply(clean_training, is.numeric)]))

dim(correlation_matrix)
```

```
## [1] 52 52
```

```
correlationmatrixdegreesoffreedom <- expand.grid(row = 1:52, col = 1:52)
#this returns the correlation matrix in matrix format
correlationmatrixdegreesoffreedom$correlation <- as.vector(correlation_matrix)
removehighcorrelation <- findCorrelation(correlation_matrix, cutoff = .7, verbose = TRUE)
```

```
## Considering row    10 column    1 value    0.992
##   Flagging column    10
## Considering row    1 column    9 value    0.925
##   Flagging column    1
## Considering row    9 column   22 value    0.722
##   Flagging column    9
## Considering row   22 column    4 value    0.759
##   Flagging column   22
## Considering row    4 column    3 value    0.762
##   Flagging column    4
## Considering row    3 column   36 value    0.23
## Considering row    3 column    8 value    0.708
##   Flagging column    3
## Considering row   36 column    8 value    0.514
## Considering row   36 column    2 value    0.538
## Considering row   36 column   11 value    0.503
## Considering row   36 column   29 value    0.849
##   Flagging column   36
## Considering row    8 column    2 value    0.966
##   Flagging column    8
```

| | | | | | | |
|----|-----------------|----|--------|----|-------|-------|
| ## | Considering row | 2 | column | 11 | value | 0.884 |
| ## | Flagging column | 2 | | | | |
| ## | Considering row | 11 | column | 29 | value | 0.607 |
| ## | Considering row | 11 | column | 37 | value | 0.347 |
| ## | Considering row | 11 | column | 35 | value | 0.421 |
| ## | Considering row | 11 | column | 38 | value | 0.256 |
| ## | Considering row | 11 | column | 30 | value | 0.337 |
| ## | Considering row | 11 | column | 47 | value | 0.172 |
| ## | Considering row | 11 | column | 21 | value | 0.162 |
| ## | Considering row | 11 | column | 5 | value | 0.426 |
| ## | Considering row | 11 | column | 34 | value | 0.192 |
| ## | Considering row | 11 | column | 6 | value | 0.404 |
| ## | Considering row | 11 | column | 20 | value | 0.38 |
| ## | Considering row | 11 | column | 39 | value | 0.223 |
| ## | Considering row | 11 | column | 44 | value | 0.545 |
| ## | Considering row | 11 | column | 14 | value | 0.209 |
| ## | Considering row | 11 | column | 41 | value | 0.241 |
| ## | Considering row | 11 | column | 52 | value | 0.041 |
| ## | Considering row | 11 | column | 23 | value | 0.005 |
| ## | Considering row | 11 | column | 28 | value | 0.252 |
| ## | Considering row | 11 | column | 7 | value | 0.022 |
| ## | Considering row | 11 | column | 25 | value | 0.009 |
| ## | Considering row | 11 | column | 12 | value | 0.049 |
| ## | Considering row | 11 | column | 49 | value | 0.298 |
| ## | Considering row | 11 | column | 42 | value | 0.028 |
| ## | Considering row | 11 | column | 13 | value | 0.115 |
| ## | Considering row | 11 | column | 27 | value | 0.292 |
| ## | Considering row | 11 | column | 48 | value | 0.327 |
| ## | Considering row | 11 | column | 24 | value | 0.009 |
| ## | Considering row | 11 | column | 16 | value | 0.125 |
| ## | Considering row | 11 | column | 26 | value | 0.009 |
| ## | Considering row | 11 | column | 40 | value | 0.157 |
| ## | Considering row | 11 | column | 17 | value | 0.085 |
| ## | Considering row | 11 | column | 50 | value | 0.03 |
| ## | Considering row | 11 | column | 15 | value | 0.177 |
| ## | Considering row | 11 | column | 19 | value | 0.146 |
| ## | Considering row | 11 | column | 51 | value | 0.075 |
| ## | Considering row | 11 | column | 43 | value | 0.259 |
| ## | Considering row | 11 | column | 32 | value | 0.049 |
| ## | Considering row | 11 | column | 46 | value | 0.093 |
| ## | Considering row | 11 | column | 45 | value | 0.068 |
| ## | Considering row | 11 | column | 31 | value | 0.011 |
| ## | Considering row | 11 | column | 33 | value | 0.006 |
| ## | Considering row | 11 | column | 18 | value | 0.063 |
| ## | Considering row | 29 | column | 37 | value | 0.577 |
| ## | Considering row | 29 | column | 35 | value | 0.541 |
| ## | Considering row | 29 | column | 38 | value | 0.442 |
| ## | Considering row | 29 | column | 30 | value | 0.527 |
| ## | Considering row | 29 | column | 47 | value | 0.01 |
| ## | Considering row | 29 | column | 21 | value | 0.327 |
| ## | Considering row | 29 | column | 5 | value | 0.438 |
| ## | Considering row | 29 | column | 34 | value | 0.545 |
| ## | Considering row | 29 | column | 6 | value | 0.293 |
| ## | Considering row | 29 | column | 20 | value | 0.182 |

| | | | | | | |
|----|-----------------|----|--------|----|-------|-------|
| ## | Considering row | 29 | column | 39 | value | 0.108 |
| ## | Considering row | 29 | column | 44 | value | 0.323 |
| ## | Considering row | 29 | column | 14 | value | 0.28 |
| ## | Considering row | 29 | column | 41 | value | 0.28 |
| ## | Considering row | 29 | column | 52 | value | 0.193 |
| ## | Considering row | 29 | column | 23 | value | 0.142 |
| ## | Considering row | 29 | column | 28 | value | 0.517 |
| ## | Considering row | 29 | column | 7 | value | 0.245 |
| ## | Considering row | 29 | column | 25 | value | 0.103 |
| ## | Considering row | 29 | column | 12 | value | 0.244 |
| ## | Considering row | 29 | column | 49 | value | 0.019 |
| ## | Considering row | 29 | column | 42 | value | 0.056 |
| ## | Considering row | 29 | column | 13 | value | 0.213 |
| ## | Considering row | 29 | column | 27 | value | 0.277 |
| ## | Considering row | 29 | column | 48 | value | 0.191 |
| ## | Considering row | 29 | column | 24 | value | 0.059 |
| ## | Considering row | 29 | column | 16 | value | 0.144 |
| ## | Considering row | 29 | column | 26 | value | 0.05 |
| ## | Considering row | 29 | column | 40 | value | 0.013 |
| ## | Considering row | 29 | column | 17 | value | 0.029 |
| ## | Considering row | 29 | column | 50 | value | 0.099 |
| ## | Considering row | 29 | column | 15 | value | 0.178 |
| ## | Considering row | 29 | column | 19 | value | 0.049 |
| ## | Considering row | 29 | column | 51 | value | 0.063 |
| ## | Considering row | 29 | column | 43 | value | 0.189 |
| ## | Considering row | 29 | column | 32 | value | 0.064 |
| ## | Considering row | 29 | column | 46 | value | 0.042 |
| ## | Considering row | 29 | column | 45 | value | 0.038 |
| ## | Considering row | 29 | column | 31 | value | 0.014 |
| ## | Considering row | 29 | column | 33 | value | 0.017 |
| ## | Considering row | 29 | column | 18 | value | 0.054 |
| ## | Considering row | 37 | column | 35 | value | 0.269 |
| ## | Considering row | 37 | column | 38 | value | 0.769 |
| ## | Flagging column | 37 | | | | |
| ## | Considering row | 35 | column | 38 | value | 0.493 |
| ## | Considering row | 35 | column | 30 | value | 0.773 |
| ## | Flagging column | 35 | | | | |
| ## | Considering row | 38 | column | 30 | value | 0.161 |
| ## | Considering row | 38 | column | 47 | value | 0.157 |
| ## | Considering row | 38 | column | 21 | value | 0.424 |
| ## | Considering row | 38 | column | 5 | value | 0.781 |
| ## | Flagging column | 38 | | | | |
| ## | Considering row | 30 | column | 47 | value | 0.262 |
| ## | Considering row | 30 | column | 21 | value | 0.179 |
| ## | Considering row | 30 | column | 5 | value | 0.067 |
| ## | Considering row | 30 | column | 34 | value | 0.679 |
| ## | Considering row | 30 | column | 6 | value | 0.068 |
| ## | Considering row | 30 | column | 20 | value | 0.093 |
| ## | Considering row | 30 | column | 39 | value | 0.148 |
| ## | Considering row | 30 | column | 44 | value | 0.149 |
| ## | Considering row | 30 | column | 14 | value | 0.155 |
| ## | Considering row | 30 | column | 41 | value | 0.345 |
| ## | Considering row | 30 | column | 52 | value | 0.3 |
| ## | Considering row | 30 | column | 23 | value | 0.112 |

| | | | | | | |
|----|-----------------|----|--------|----|-------|-------|
| ## | Considering row | 30 | column | 28 | value | 0.405 |
| ## | Considering row | 30 | column | 7 | value | 0.113 |
| ## | Considering row | 30 | column | 25 | value | 0.222 |
| ## | Considering row | 30 | column | 12 | value | 0.367 |
| ## | Considering row | 30 | column | 49 | value | 0.243 |
| ## | Considering row | 30 | column | 42 | value | 0.229 |
| ## | Considering row | 30 | column | 13 | value | 0.212 |
| ## | Considering row | 30 | column | 27 | value | 0.36 |
| ## | Considering row | 30 | column | 48 | value | 0.176 |
| ## | Considering row | 30 | column | 24 | value | 0.109 |
| ## | Considering row | 30 | column | 16 | value | 0.063 |
| ## | Considering row | 30 | column | 26 | value | 0.037 |
| ## | Considering row | 30 | column | 40 | value | 0.219 |
| ## | Considering row | 30 | column | 17 | value | 0.137 |
| ## | Considering row | 30 | column | 50 | value | 0.086 |
| ## | Considering row | 30 | column | 15 | value | 0.197 |
| ## | Considering row | 30 | column | 19 | value | 0.03 |
| ## | Considering row | 30 | column | 51 | value | 0.087 |
| ## | Considering row | 30 | column | 43 | value | 0.126 |
| ## | Considering row | 30 | column | 32 | value | 0.074 |
| ## | Considering row | 30 | column | 46 | value | 0.058 |
| ## | Considering row | 30 | column | 45 | value | 0.06 |
| ## | Considering row | 30 | column | 31 | value | 0.024 |
| ## | Considering row | 30 | column | 33 | value | 0.006 |
| ## | Considering row | 30 | column | 18 | value | 0.01 |
| ## | Considering row | 47 | column | 21 | value | 0.147 |
| ## | Considering row | 47 | column | 5 | value | 0.212 |
| ## | Considering row | 47 | column | 34 | value | 0.203 |
| ## | Considering row | 47 | column | 6 | value | 0.379 |
| ## | Considering row | 47 | column | 20 | value | 0.422 |
| ## | Considering row | 47 | column | 39 | value | 0.25 |
| ## | Considering row | 47 | column | 44 | value | 0.122 |
| ## | Considering row | 47 | column | 14 | value | 0.226 |
| ## | Considering row | 47 | column | 41 | value | 0.477 |
| ## | Considering row | 47 | column | 52 | value | 0.066 |
| ## | Considering row | 47 | column | 23 | value | 0.153 |
| ## | Considering row | 47 | column | 28 | value | 0.083 |
| ## | Considering row | 47 | column | 7 | value | 0.134 |
| ## | Considering row | 47 | column | 25 | value | 0.207 |
| ## | Considering row | 47 | column | 12 | value | 0.07 |
| ## | Considering row | 47 | column | 49 | value | 0.202 |
| ## | Considering row | 47 | column | 42 | value | 0.285 |
| ## | Considering row | 47 | column | 13 | value | 0.083 |
| ## | Considering row | 47 | column | 27 | value | 0.001 |
| ## | Considering row | 47 | column | 48 | value | 0.306 |
| ## | Considering row | 47 | column | 24 | value | 0.238 |
| ## | Considering row | 47 | column | 16 | value | 0.162 |
| ## | Considering row | 47 | column | 26 | value | 0.045 |
| ## | Considering row | 47 | column | 40 | value | 0.288 |
| ## | Considering row | 47 | column | 17 | value | 0.246 |
| ## | Considering row | 47 | column | 50 | value | 0.68 |
| ## | Considering row | 47 | column | 15 | value | 0.021 |
| ## | Considering row | 47 | column | 19 | value | 0.141 |
| ## | Considering row | 47 | column | 51 | value | 0.21 |

| | | | | | | |
|----|-----------------|----|--------|----|-------|-------|
| ## | Considering row | 47 | column | 43 | value | 0.203 |
| ## | Considering row | 47 | column | 32 | value | 0.024 |
| ## | Considering row | 47 | column | 46 | value | 0.029 |
| ## | Considering row | 47 | column | 45 | value | 0.047 |
| ## | Considering row | 47 | column | 31 | value | 0.047 |
| ## | Considering row | 47 | column | 33 | value | 0.032 |
| ## | Considering row | 47 | column | 18 | value | 0.043 |
| ## | Considering row | 21 | column | 5 | value | 0.373 |
| ## | Considering row | 21 | column | 34 | value | 0.245 |
| ## | Considering row | 21 | column | 6 | value | 0.127 |
| ## | Considering row | 21 | column | 20 | value | 0.003 |
| ## | Considering row | 21 | column | 39 | value | 0.104 |
| ## | Considering row | 21 | column | 44 | value | 0.062 |
| ## | Considering row | 21 | column | 14 | value | 0.174 |
| ## | Considering row | 21 | column | 41 | value | 0.381 |
| ## | Considering row | 21 | column | 52 | value | 0.042 |
| ## | Considering row | 21 | column | 23 | value | 0.146 |
| ## | Considering row | 21 | column | 28 | value | 0.259 |
| ## | Considering row | 21 | column | 7 | value | 0.271 |
| ## | Considering row | 21 | column | 25 | value | 0.7 |
| ## | Considering row | 21 | column | 12 | value | 0.112 |
| ## | Considering row | 21 | column | 49 | value | 0.068 |
| ## | Considering row | 21 | column | 42 | value | 0.037 |
| ## | Considering row | 21 | column | 13 | value | 0.132 |
| ## | Considering row | 21 | column | 27 | value | 0.074 |
| ## | Considering row | 21 | column | 48 | value | 0.048 |
| ## | Considering row | 21 | column | 24 | value | 0.814 |
| ## | Flagging column | 21 | | | | |
| ## | Considering row | 5 | column | 34 | value | 0.136 |
| ## | Considering row | 5 | column | 6 | value | 0.333 |
| ## | Considering row | 5 | column | 20 | value | 0.282 |
| ## | Considering row | 5 | column | 39 | value | 0.225 |
| ## | Considering row | 5 | column | 44 | value | 0.125 |
| ## | Considering row | 5 | column | 14 | value | 0.251 |
| ## | Considering row | 5 | column | 41 | value | 0.156 |
| ## | Considering row | 5 | column | 52 | value | 0.111 |
| ## | Considering row | 5 | column | 23 | value | 0.265 |
| ## | Considering row | 5 | column | 28 | value | 0.196 |
| ## | Considering row | 5 | column | 7 | value | 0.34 |
| ## | Considering row | 5 | column | 25 | value | 0.139 |
| ## | Considering row | 5 | column | 12 | value | 0.11 |
| ## | Considering row | 5 | column | 49 | value | 0.342 |
| ## | Considering row | 5 | column | 42 | value | 0.18 |
| ## | Considering row | 5 | column | 13 | value | 0.227 |
| ## | Considering row | 5 | column | 27 | value | 0.254 |
| ## | Considering row | 5 | column | 48 | value | 0.043 |
| ## | Considering row | 5 | column | 24 | value | 0.026 |
| ## | Considering row | 5 | column | 16 | value | 0.148 |
| ## | Considering row | 5 | column | 26 | value | 0.02 |
| ## | Considering row | 5 | column | 40 | value | 0.215 |
| ## | Considering row | 5 | column | 17 | value | 0.002 |
| ## | Considering row | 5 | column | 50 | value | 0.049 |
| ## | Considering row | 5 | column | 15 | value | 0.031 |
| ## | Considering row | 5 | column | 19 | value | 0.048 |

| | | | | | | |
|----|-----------------|----|--------|----|-------|-------|
| ## | Considering row | 5 | column | 51 | value | 0.019 |
| ## | Considering row | 5 | column | 43 | value | 0.054 |
| ## | Considering row | 5 | column | 32 | value | 0.122 |
| ## | Considering row | 5 | column | 46 | value | 0.019 |
| ## | Considering row | 5 | column | 45 | value | 0.027 |
| ## | Considering row | 5 | column | 31 | value | 0.073 |
| ## | Considering row | 5 | column | 33 | value | 0.022 |
| ## | Considering row | 5 | column | 18 | value | 0.064 |
| ## | Considering row | 34 | column | 6 | value | 0.012 |
| ## | Considering row | 34 | column | 20 | value | 0.067 |
| ## | Considering row | 34 | column | 39 | value | 0.052 |
| ## | Considering row | 34 | column | 44 | value | 0.069 |
| ## | Considering row | 34 | column | 14 | value | 0.254 |
| ## | Considering row | 34 | column | 41 | value | 0.37 |
| ## | Considering row | 34 | column | 52 | value | 0.293 |
| ## | Considering row | 34 | column | 23 | value | 0.122 |
| ## | Considering row | 34 | column | 28 | value | 0.808 |
| ## | Flagging column | 34 | | | | |
| ## | Considering row | 6 | column | 20 | value | 0.488 |
| ## | Considering row | 6 | column | 39 | value | 0.166 |
| ## | Considering row | 6 | column | 44 | value | 0.318 |
| ## | Considering row | 6 | column | 14 | value | 0.375 |
| ## | Considering row | 6 | column | 41 | value | 0.021 |
| ## | Considering row | 6 | column | 52 | value | 0.119 |
| ## | Considering row | 6 | column | 23 | value | 0.051 |
| ## | Considering row | 6 | column | 28 | value | 0.136 |
| ## | Considering row | 6 | column | 7 | value | 0.342 |
| ## | Considering row | 6 | column | 25 | value | 0.087 |
| ## | Considering row | 6 | column | 12 | value | 0.057 |
| ## | Considering row | 6 | column | 49 | value | 0.264 |
| ## | Considering row | 6 | column | 42 | value | 0.265 |
| ## | Considering row | 6 | column | 13 | value | 0.124 |
| ## | Considering row | 6 | column | 27 | value | 0.068 |
| ## | Considering row | 6 | column | 48 | value | 0.013 |
| ## | Considering row | 6 | column | 24 | value | 0.078 |
| ## | Considering row | 6 | column | 16 | value | 0.229 |
| ## | Considering row | 6 | column | 26 | value | 0.013 |
| ## | Considering row | 6 | column | 40 | value | 0.215 |
| ## | Considering row | 6 | column | 17 | value | 0.159 |
| ## | Considering row | 6 | column | 50 | value | 0.032 |
| ## | Considering row | 6 | column | 15 | value | 0.009 |
| ## | Considering row | 6 | column | 19 | value | 0.158 |
| ## | Considering row | 6 | column | 51 | value | 0.012 |
| ## | Considering row | 6 | column | 43 | value | 0.067 |
| ## | Considering row | 6 | column | 32 | value | 0.038 |
| ## | Considering row | 6 | column | 46 | value | 0.016 |
| ## | Considering row | 6 | column | 45 | value | 0.02 |
| ## | Considering row | 6 | column | 31 | value | 0.022 |
| ## | Considering row | 6 | column | 33 | value | 0.01 |
| ## | Considering row | 6 | column | 18 | value | 0.081 |
| ## | Considering row | 20 | column | 39 | value | 0.222 |
| ## | Considering row | 20 | column | 44 | value | 0.261 |
| ## | Considering row | 20 | column | 14 | value | 0.354 |
| ## | Considering row | 20 | column | 41 | value | 0.022 |

| | | | | | | |
|----|-----------------|----|--------|----|-------|-------|
| ## | Considering row | 20 | column | 52 | value | 0.123 |
| ## | Considering row | 20 | column | 23 | value | 0.004 |
| ## | Considering row | 20 | column | 28 | value | 0.053 |
| ## | Considering row | 20 | column | 7 | value | 0.105 |
| ## | Considering row | 20 | column | 25 | value | 0.11 |
| ## | Considering row | 20 | column | 12 | value | 0.016 |
| ## | Considering row | 20 | column | 49 | value | 0.205 |
| ## | Considering row | 20 | column | 42 | value | 0.246 |
| ## | Considering row | 20 | column | 13 | value | 0.141 |
| ## | Considering row | 20 | column | 27 | value | 0.052 |
| ## | Considering row | 20 | column | 48 | value | 0.008 |
| ## | Considering row | 20 | column | 24 | value | 0.088 |
| ## | Considering row | 20 | column | 16 | value | 0.231 |
| ## | Considering row | 20 | column | 26 | value | 0.063 |
| ## | Considering row | 20 | column | 40 | value | 0.192 |
| ## | Considering row | 20 | column | 17 | value | 0.11 |
| ## | Considering row | 20 | column | 50 | value | 0.121 |
| ## | Considering row | 20 | column | 15 | value | 0.01 |
| ## | Considering row | 20 | column | 19 | value | 0.477 |
| ## | Considering row | 20 | column | 51 | value | 0.053 |
| ## | Considering row | 20 | column | 43 | value | 0.063 |
| ## | Considering row | 20 | column | 32 | value | 0.08 |
| ## | Considering row | 20 | column | 46 | value | 0.018 |
| ## | Considering row | 20 | column | 45 | value | 0.019 |
| ## | Considering row | 20 | column | 31 | value | 0.033 |
| ## | Considering row | 20 | column | 33 | value | 0.01 |
| ## | Considering row | 20 | column | 18 | value | 0.334 |
| ## | Considering row | 39 | column | 44 | value | 0.094 |
| ## | Considering row | 39 | column | 14 | value | 0.355 |
| ## | Considering row | 39 | column | 41 | value | 0.171 |
| ## | Considering row | 39 | column | 52 | value | 0.584 |
| ## | Considering row | 39 | column | 23 | value | 0.27 |
| ## | Considering row | 39 | column | 28 | value | 0.069 |
| ## | Considering row | 39 | column | 7 | value | 0.259 |
| ## | Considering row | 39 | column | 25 | value | 0.134 |
| ## | Considering row | 39 | column | 12 | value | 0.185 |
| ## | Considering row | 39 | column | 49 | value | 0.606 |
| ## | Considering row | 39 | column | 42 | value | 0.151 |
| ## | Considering row | 39 | column | 13 | value | 0.306 |
| ## | Considering row | 39 | column | 27 | value | 0.132 |
| ## | Considering row | 39 | column | 48 | value | 0.135 |
| ## | Considering row | 39 | column | 24 | value | 0.009 |
| ## | Considering row | 39 | column | 16 | value | 0.241 |
| ## | Considering row | 39 | column | 26 | value | 0.092 |
| ## | Considering row | 39 | column | 40 | value | 0.056 |
| ## | Considering row | 39 | column | 17 | value | 0.134 |
| ## | Considering row | 39 | column | 50 | value | 0.241 |
| ## | Considering row | 39 | column | 15 | value | 0.012 |
| ## | Considering row | 39 | column | 19 | value | 0.099 |
| ## | Considering row | 39 | column | 51 | value | 0.043 |
| ## | Considering row | 39 | column | 43 | value | 0.107 |
| ## | Considering row | 39 | column | 32 | value | 0.082 |
| ## | Considering row | 39 | column | 46 | value | 0.046 |
| ## | Considering row | 39 | column | 45 | value | 0.017 |

| | | | | | | |
|----|-----------------|----|--------|----|-------|-------|
| ## | Considering row | 39 | column | 31 | value | 0.01 |
| ## | Considering row | 39 | column | 33 | value | 0.004 |
| ## | Considering row | 39 | column | 18 | value | 0.001 |
| ## | Considering row | 44 | column | 14 | value | 0.173 |
| ## | Considering row | 44 | column | 41 | value | 0.137 |
| ## | Considering row | 44 | column | 52 | value | 0.185 |
| ## | Considering row | 44 | column | 23 | value | 0.17 |
| ## | Considering row | 44 | column | 28 | value | 0.104 |
| ## | Considering row | 44 | column | 7 | value | 0.1 |
| ## | Considering row | 44 | column | 25 | value | 0.088 |
| ## | Considering row | 44 | column | 12 | value | 0.028 |
| ## | Considering row | 44 | column | 49 | value | 0.002 |
| ## | Considering row | 44 | column | 42 | value | 0.014 |
| ## | Considering row | 44 | column | 13 | value | 0.128 |
| ## | Considering row | 44 | column | 27 | value | 0.177 |
| ## | Considering row | 44 | column | 48 | value | 0.297 |
| ## | Considering row | 44 | column | 24 | value | 0.015 |
| ## | Considering row | 44 | column | 16 | value | 0.111 |
| ## | Considering row | 44 | column | 26 | value | 0.093 |
| ## | Considering row | 44 | column | 40 | value | 0.05 |
| ## | Considering row | 44 | column | 17 | value | 0.171 |
| ## | Considering row | 44 | column | 50 | value | 0.029 |
| ## | Considering row | 44 | column | 15 | value | 0.114 |
| ## | Considering row | 44 | column | 19 | value | 0.118 |
| ## | Considering row | 44 | column | 51 | value | 0.098 |
| ## | Considering row | 44 | column | 43 | value | 0.23 |
| ## | Considering row | 44 | column | 32 | value | 0.174 |
| ## | Considering row | 44 | column | 46 | value | 0.251 |
| ## | Considering row | 44 | column | 45 | value | 0.435 |
| ## | Considering row | 44 | column | 31 | value | 0.251 |
| ## | Considering row | 44 | column | 33 | value | 0.241 |
| ## | Considering row | 44 | column | 18 | value | 0.041 |
| ## | Considering row | 14 | column | 41 | value | 0.166 |
| ## | Considering row | 14 | column | 52 | value | 0.332 |
| ## | Considering row | 14 | column | 23 | value | 0.069 |
| ## | Considering row | 14 | column | 28 | value | 0.229 |
| ## | Considering row | 14 | column | 7 | value | 0.03 |
| ## | Considering row | 14 | column | 25 | value | 0.124 |
| ## | Considering row | 14 | column | 12 | value | 0.165 |
| ## | Considering row | 14 | column | 49 | value | 0.07 |
| ## | Considering row | 14 | column | 42 | value | 0.237 |
| ## | Considering row | 14 | column | 13 | value | 0.213 |
| ## | Considering row | 14 | column | 27 | value | 0.149 |
| ## | Considering row | 14 | column | 48 | value | 0.069 |
| ## | Considering row | 14 | column | 24 | value | 0.055 |
| ## | Considering row | 14 | column | 16 | value | 0.407 |
| ## | Considering row | 14 | column | 26 | value | 0.099 |
| ## | Considering row | 14 | column | 40 | value | 0.076 |
| ## | Considering row | 14 | column | 17 | value | 0.058 |
| ## | Considering row | 14 | column | 50 | value | 0.051 |
| ## | Considering row | 14 | column | 15 | value | 0.041 |
| ## | Considering row | 14 | column | 19 | value | 0.082 |
| ## | Considering row | 14 | column | 51 | value | 0.093 |
| ## | Considering row | 14 | column | 43 | value | 0.012 |

| | | | | | | |
|----|-----------------|----|--------|----|-------|-------|
| ## | Considering row | 14 | column | 32 | value | 0.116 |
| ## | Considering row | 14 | column | 46 | value | 0.011 |
| ## | Considering row | 14 | column | 45 | value | 0.032 |
| ## | Considering row | 14 | column | 31 | value | 0.01 |
| ## | Considering row | 14 | column | 33 | value | 0.002 |
| ## | Considering row | 14 | column | 18 | value | 0.014 |
| ## | Considering row | 41 | column | 52 | value | 0.016 |
| ## | Considering row | 41 | column | 23 | value | 0.147 |
| ## | Considering row | 41 | column | 28 | value | 0.291 |
| ## | Considering row | 41 | column | 7 | value | 0.159 |
| ## | Considering row | 41 | column | 25 | value | 0.277 |
| ## | Considering row | 41 | column | 12 | value | 0.133 |
| ## | Considering row | 41 | column | 49 | value | 0.041 |
| ## | Considering row | 41 | column | 42 | value | 0.221 |
| ## | Considering row | 41 | column | 13 | value | 0.095 |
| ## | Considering row | 41 | column | 27 | value | 0.108 |
| ## | Considering row | 41 | column | 48 | value | 0.257 |
| ## | Considering row | 41 | column | 24 | value | 0.347 |
| ## | Considering row | 41 | column | 16 | value | 0.061 |
| ## | Considering row | 41 | column | 26 | value | 0.137 |
| ## | Considering row | 41 | column | 40 | value | 0.054 |
| ## | Considering row | 41 | column | 17 | value | 0.187 |
| ## | Considering row | 41 | column | 50 | value | 0.439 |
| ## | Considering row | 41 | column | 15 | value | 0.155 |
| ## | Considering row | 41 | column | 19 | value | 0.031 |
| ## | Considering row | 41 | column | 51 | value | 0.271 |
| ## | Considering row | 41 | column | 43 | value | 0.179 |
| ## | Considering row | 41 | column | 32 | value | 0.006 |
| ## | Considering row | 41 | column | 46 | value | 0.024 |
| ## | Considering row | 41 | column | 45 | value | 0.01 |
| ## | Considering row | 41 | column | 31 | value | 0.003 |
| ## | Considering row | 41 | column | 33 | value | 0.001 |
| ## | Considering row | 41 | column | 18 | value | 0.068 |
| ## | Considering row | 52 | column | 23 | value | 0.106 |
| ## | Considering row | 52 | column | 28 | value | 0.21 |
| ## | Considering row | 52 | column | 7 | value | 0.111 |
| ## | Considering row | 52 | column | 25 | value | 0.126 |
| ## | Considering row | 52 | column | 12 | value | 0.381 |
| ## | Considering row | 52 | column | 49 | value | 0.547 |
| ## | Considering row | 52 | column | 42 | value | 0.061 |
| ## | Considering row | 52 | column | 13 | value | 0.404 |
| ## | Considering row | 52 | column | 27 | value | 0.144 |
| ## | Considering row | 52 | column | 48 | value | 0.283 |
| ## | Considering row | 52 | column | 24 | value | 0.043 |
| ## | Considering row | 52 | column | 16 | value | 0.236 |
| ## | Considering row | 52 | column | 26 | value | 0.009 |
| ## | Considering row | 52 | column | 40 | value | 0.407 |
| ## | Considering row | 52 | column | 17 | value | 0.094 |
| ## | Considering row | 52 | column | 50 | value | 0.126 |
| ## | Considering row | 52 | column | 15 | value | 0.022 |
| ## | Considering row | 52 | column | 19 | value | 0.101 |
| ## | Considering row | 52 | column | 51 | value | 0.239 |
| ## | Considering row | 52 | column | 43 | value | 0.014 |
| ## | Considering row | 52 | column | 32 | value | 0.083 |

| | | | | | | |
|----|-----------------|----|--------|----|-------|-------|
| ## | Considering row | 52 | column | 46 | value | 0.002 |
| ## | Considering row | 52 | column | 45 | value | 0.065 |
| ## | Considering row | 52 | column | 31 | value | 0.048 |
| ## | Considering row | 52 | column | 33 | value | 0.025 |
| ## | Considering row | 52 | column | 18 | value | 0.02 |
| ## | Considering row | 23 | column | 28 | value | 0.084 |
| ## | Considering row | 23 | column | 7 | value | 0.24 |
| ## | Considering row | 23 | column | 25 | value | 0.553 |
| ## | Considering row | 23 | column | 12 | value | 0.093 |
| ## | Considering row | 23 | column | 49 | value | 0.077 |
| ## | Considering row | 23 | column | 42 | value | 0.05 |
| ## | Considering row | 23 | column | 13 | value | 0.042 |
| ## | Considering row | 23 | column | 27 | value | 0.12 |
| ## | Considering row | 23 | column | 48 | value | 0.047 |
| ## | Considering row | 23 | column | 24 | value | 0.149 |
| ## | Considering row | 23 | column | 16 | value | 0.028 |
| ## | Considering row | 23 | column | 26 | value | 0.779 |
| ## | Flagging column | 23 | | | | |
| ## | Considering row | 28 | column | 7 | value | 0.222 |
| ## | Considering row | 28 | column | 25 | value | 0.155 |
| ## | Considering row | 28 | column | 12 | value | 0.243 |
| ## | Considering row | 28 | column | 49 | value | 0.122 |
| ## | Considering row | 28 | column | 42 | value | 0.093 |
| ## | Considering row | 28 | column | 13 | value | 0.174 |
| ## | Considering row | 28 | column | 27 | value | 0.213 |
| ## | Considering row | 28 | column | 48 | value | 0.093 |
| ## | Considering row | 28 | column | 24 | value | 0.127 |
| ## | Considering row | 28 | column | 16 | value | 0.087 |
| ## | Considering row | 28 | column | 26 | value | 0.087 |
| ## | Considering row | 28 | column | 40 | value | 0.072 |
| ## | Considering row | 28 | column | 17 | value | 0.072 |
| ## | Considering row | 28 | column | 50 | value | 0.034 |
| ## | Considering row | 28 | column | 15 | value | 0.153 |
| ## | Considering row | 28 | column | 19 | value | 0.005 |
| ## | Considering row | 28 | column | 51 | value | 0.149 |
| ## | Considering row | 28 | column | 43 | value | 0.015 |
| ## | Considering row | 28 | column | 32 | value | 0.1 |
| ## | Considering row | 28 | column | 46 | value | 0.014 |
| ## | Considering row | 28 | column | 45 | value | 0.029 |
| ## | Considering row | 28 | column | 31 | value | 0.005 |
| ## | Considering row | 28 | column | 33 | value | 0.003 |
| ## | Considering row | 28 | column | 18 | value | 0.03 |
| ## | Considering row | 7 | column | 25 | value | 0.037 |
| ## | Considering row | 7 | column | 12 | value | 0.129 |
| ## | Considering row | 7 | column | 49 | value | 0.097 |
| ## | Considering row | 7 | column | 42 | value | 0.086 |
| ## | Considering row | 7 | column | 13 | value | 0.079 |
| ## | Considering row | 7 | column | 27 | value | 0.072 |
| ## | Considering row | 7 | column | 48 | value | 0.005 |
| ## | Considering row | 7 | column | 24 | value | 0.025 |
| ## | Considering row | 7 | column | 16 | value | 0.019 |
| ## | Considering row | 7 | column | 26 | value | 0.02 |
| ## | Considering row | 7 | column | 40 | value | 0.004 |
| ## | Considering row | 7 | column | 17 | value | 0.09 |

| | | | | | | |
|----|-----------------|----|--------|----|-------|-------|
| ## | Considering row | 7 | column | 50 | value | 0.121 |
| ## | Considering row | 7 | column | 15 | value | 0.032 |
| ## | Considering row | 7 | column | 19 | value | 0.014 |
| ## | Considering row | 7 | column | 51 | value | 0.006 |
| ## | Considering row | 7 | column | 43 | value | 0.014 |
| ## | Considering row | 7 | column | 32 | value | 0.041 |
| ## | Considering row | 7 | column | 46 | value | 0.003 |
| ## | Considering row | 7 | column | 45 | value | 0.031 |
| ## | Considering row | 7 | column | 31 | value | 0.01 |
| ## | Considering row | 7 | column | 33 | value | 0 |
| ## | Considering row | 7 | column | 18 | value | 0.097 |
| ## | Considering row | 25 | column | 12 | value | 0.092 |
| ## | Considering row | 25 | column | 49 | value | 0.178 |
| ## | Considering row | 25 | column | 42 | value | 0.149 |
| ## | Considering row | 25 | column | 13 | value | 0.074 |
| ## | Considering row | 25 | column | 27 | value | 0.029 |
| ## | Considering row | 25 | column | 48 | value | 0.076 |
| ## | Considering row | 25 | column | 24 | value | 0.792 |
| ## | Flagging column | 25 | | | | |
| ## | Considering row | 12 | column | 49 | value | 0.352 |
| ## | Considering row | 12 | column | 42 | value | 0.087 |
| ## | Considering row | 12 | column | 13 | value | 0.779 |
| ## | Flagging column | 12 | | | | |
| ## | Considering row | 49 | column | 42 | value | 0.135 |
| ## | Considering row | 49 | column | 13 | value | 0.367 |
| ## | Considering row | 49 | column | 27 | value | 0.056 |
| ## | Considering row | 49 | column | 48 | value | 0.041 |
| ## | Considering row | 49 | column | 24 | value | 0.035 |
| ## | Considering row | 49 | column | 16 | value | 0.09 |
| ## | Considering row | 49 | column | 26 | value | 0.036 |
| ## | Considering row | 49 | column | 40 | value | 0.277 |
| ## | Considering row | 49 | column | 17 | value | 0.059 |
| ## | Considering row | 49 | column | 50 | value | 0.074 |
| ## | Considering row | 49 | column | 15 | value | 0.005 |
| ## | Considering row | 49 | column | 19 | value | 0.076 |
| ## | Considering row | 49 | column | 51 | value | 0.032 |
| ## | Considering row | 49 | column | 43 | value | 0 |
| ## | Considering row | 49 | column | 32 | value | 0.045 |
| ## | Considering row | 49 | column | 46 | value | 0.044 |
| ## | Considering row | 49 | column | 45 | value | 0.001 |
| ## | Considering row | 49 | column | 31 | value | 0.032 |
| ## | Considering row | 49 | column | 33 | value | 0.004 |
| ## | Considering row | 49 | column | 18 | value | 0.056 |
| ## | Considering row | 42 | column | 13 | value | 0.016 |
| ## | Considering row | 42 | column | 27 | value | 0 |
| ## | Considering row | 42 | column | 48 | value | 0.4 |
| ## | Considering row | 42 | column | 24 | value | 0.14 |
| ## | Considering row | 42 | column | 16 | value | 0.185 |
| ## | Considering row | 42 | column | 26 | value | 0.044 |
| ## | Considering row | 42 | column | 40 | value | 0.347 |
| ## | Considering row | 42 | column | 17 | value | 0.093 |
| ## | Considering row | 42 | column | 50 | value | 0.077 |
| ## | Considering row | 42 | column | 15 | value | 0.08 |
| ## | Considering row | 42 | column | 19 | value | 0.007 |

| | | | | | | |
|----|-----------------|----|--------|----|-------|-------|
| ## | Considering row | 42 | column | 51 | value | 0.384 |
| ## | Considering row | 42 | column | 43 | value | 0.2 |
| ## | Considering row | 42 | column | 32 | value | 0.027 |
| ## | Considering row | 42 | column | 46 | value | 0.016 |
| ## | Considering row | 42 | column | 45 | value | 0.003 |
| ## | Considering row | 42 | column | 31 | value | 0.032 |
| ## | Considering row | 42 | column | 33 | value | 0.022 |
| ## | Considering row | 42 | column | 18 | value | 0.055 |
| ## | Considering row | 13 | column | 27 | value | 0.238 |
| ## | Considering row | 13 | column | 48 | value | 0.001 |
| ## | Considering row | 13 | column | 24 | value | 0.022 |
| ## | Considering row | 13 | column | 16 | value | 0.195 |
| ## | Considering row | 13 | column | 26 | value | 0.032 |
| ## | Considering row | 13 | column | 40 | value | 0.06 |
| ## | Considering row | 13 | column | 17 | value | 0.005 |
| ## | Considering row | 13 | column | 50 | value | 0.089 |
| ## | Considering row | 13 | column | 15 | value | 0.04 |
| ## | Considering row | 13 | column | 19 | value | 0.057 |
| ## | Considering row | 13 | column | 51 | value | 0.041 |
| ## | Considering row | 13 | column | 43 | value | 0.063 |
| ## | Considering row | 13 | column | 32 | value | 0.014 |
| ## | Considering row | 13 | column | 46 | value | 0.014 |
| ## | Considering row | 13 | column | 45 | value | 0.039 |
| ## | Considering row | 13 | column | 31 | value | 0.008 |
| ## | Considering row | 13 | column | 33 | value | 0.006 |
| ## | Considering row | 13 | column | 18 | value | 0.043 |
| ## | Considering row | 27 | column | 48 | value | 0.085 |
| ## | Considering row | 27 | column | 24 | value | 0.095 |
| ## | Considering row | 27 | column | 16 | value | 0.125 |
| ## | Considering row | 27 | column | 26 | value | 0.053 |
| ## | Considering row | 27 | column | 40 | value | 0.024 |
| ## | Considering row | 27 | column | 17 | value | 0.005 |
| ## | Considering row | 27 | column | 50 | value | 0.014 |
| ## | Considering row | 27 | column | 15 | value | 0.022 |
| ## | Considering row | 27 | column | 19 | value | 0.013 |
| ## | Considering row | 27 | column | 51 | value | 0.029 |
| ## | Considering row | 27 | column | 43 | value | 0.187 |
| ## | Considering row | 27 | column | 32 | value | 0.043 |
| ## | Considering row | 27 | column | 46 | value | 0.024 |
| ## | Considering row | 27 | column | 45 | value | 0.001 |
| ## | Considering row | 27 | column | 31 | value | 0.006 |
| ## | Considering row | 27 | column | 33 | value | 0.001 |
| ## | Considering row | 27 | column | 18 | value | 0.02 |
| ## | Considering row | 48 | column | 24 | value | 0.086 |
| ## | Considering row | 48 | column | 16 | value | 0.025 |
| ## | Considering row | 48 | column | 26 | value | 0.066 |
| ## | Considering row | 48 | column | 40 | value | 0.247 |
| ## | Considering row | 48 | column | 17 | value | 0.035 |
| ## | Considering row | 48 | column | 50 | value | 0.132 |
| ## | Considering row | 48 | column | 15 | value | 0.098 |
| ## | Considering row | 48 | column | 19 | value | 0.12 |
| ## | Considering row | 48 | column | 51 | value | 0.772 |
| ## | Flagging column | | 48 | | | |
| ## | Considering row | 24 | column | 16 | value | 0.031 |

| | | | | | | |
|----|-----------------|----|--------|----|-------|-------|
| ## | Considering row | 24 | column | 26 | value | 0.582 |
| ## | Considering row | 24 | column | 40 | value | 0.027 |
| ## | Considering row | 24 | column | 17 | value | 0.268 |
| ## | Considering row | 24 | column | 50 | value | 0.153 |
| ## | Considering row | 24 | column | 15 | value | 0.532 |
| ## | Considering row | 24 | column | 19 | value | 0.067 |
| ## | Considering row | 24 | column | 51 | value | 0.174 |
| ## | Considering row | 24 | column | 43 | value | 0.04 |
| ## | Considering row | 24 | column | 32 | value | 0.001 |
| ## | Considering row | 24 | column | 46 | value | 0.007 |
| ## | Considering row | 24 | column | 45 | value | 0.016 |
| ## | Considering row | 24 | column | 31 | value | 0.004 |
| ## | Considering row | 24 | column | 33 | value | 0.008 |
| ## | Considering row | 24 | column | 18 | value | 0.026 |
| ## | Considering row | 16 | column | 26 | value | 0.036 |
| ## | Considering row | 16 | column | 40 | value | 0.057 |
| ## | Considering row | 16 | column | 17 | value | 0.015 |
| ## | Considering row | 16 | column | 50 | value | 0.056 |
| ## | Considering row | 16 | column | 15 | value | 0.082 |
| ## | Considering row | 16 | column | 19 | value | 0.071 |
| ## | Considering row | 16 | column | 51 | value | 0.023 |
| ## | Considering row | 16 | column | 43 | value | 0.113 |
| ## | Considering row | 16 | column | 32 | value | 0.087 |
| ## | Considering row | 16 | column | 46 | value | 0.001 |
| ## | Considering row | 16 | column | 45 | value | 0.034 |
| ## | Considering row | 16 | column | 31 | value | 0.002 |
| ## | Considering row | 16 | column | 33 | value | 0.011 |
| ## | Considering row | 16 | column | 18 | value | 0.009 |
| ## | Considering row | 26 | column | 40 | value | 0.006 |
| ## | Considering row | 26 | column | 17 | value | 0.369 |
| ## | Considering row | 26 | column | 50 | value | 0.029 |
| ## | Considering row | 26 | column | 15 | value | 0.529 |
| ## | Considering row | 26 | column | 19 | value | 0.025 |
| ## | Considering row | 26 | column | 51 | value | 0.123 |
| ## | Considering row | 26 | column | 43 | value | 0.008 |
| ## | Considering row | 26 | column | 32 | value | 0.033 |
| ## | Considering row | 26 | column | 46 | value | 0.019 |
| ## | Considering row | 26 | column | 45 | value | 0.025 |
| ## | Considering row | 26 | column | 31 | value | 0.003 |
| ## | Considering row | 26 | column | 33 | value | 0.01 |
| ## | Considering row | 26 | column | 18 | value | 0.017 |
| ## | Considering row | 40 | column | 17 | value | 0.024 |
| ## | Considering row | 40 | column | 50 | value | 0.023 |
| ## | Considering row | 40 | column | 15 | value | 0.023 |
| ## | Considering row | 40 | column | 19 | value | 0.022 |
| ## | Considering row | 40 | column | 51 | value | 0.164 |
| ## | Considering row | 40 | column | 43 | value | 0.081 |
| ## | Considering row | 40 | column | 32 | value | 0.059 |
| ## | Considering row | 40 | column | 46 | value | 0.006 |
| ## | Considering row | 40 | column | 45 | value | 0.003 |
| ## | Considering row | 40 | column | 31 | value | 0.063 |
| ## | Considering row | 40 | column | 33 | value | 0.029 |
| ## | Considering row | 40 | column | 18 | value | 0.002 |
| ## | Considering row | 17 | column | 50 | value | 0.15 |

| | | | | | | |
|----|-----------------|----|--------|----|-------|-------|
| ## | Considering row | 17 | column | 15 | value | 0.031 |
| ## | Considering row | 17 | column | 19 | value | 0.076 |
| ## | Considering row | 17 | column | 51 | value | 0.002 |
| ## | Considering row | 17 | column | 43 | value | 0.074 |
| ## | Considering row | 17 | column | 32 | value | 0.049 |
| ## | Considering row | 17 | column | 46 | value | 0.019 |
| ## | Considering row | 17 | column | 45 | value | 0.031 |
| ## | Considering row | 17 | column | 31 | value | 0.005 |
| ## | Considering row | 17 | column | 33 | value | 0.007 |
| ## | Considering row | 17 | column | 18 | value | 0.013 |
| ## | Considering row | 50 | column | 15 | value | 0.011 |
| ## | Considering row | 50 | column | 19 | value | 0.096 |
| ## | Considering row | 50 | column | 51 | value | 0.297 |
| ## | Considering row | 50 | column | 43 | value | 0.263 |
| ## | Considering row | 50 | column | 32 | value | 0.003 |
| ## | Considering row | 50 | column | 46 | value | 0.003 |
| ## | Considering row | 50 | column | 45 | value | 0.003 |
| ## | Considering row | 50 | column | 31 | value | 0.001 |
| ## | Considering row | 50 | column | 33 | value | 0.005 |
| ## | Considering row | 50 | column | 18 | value | 0.069 |
| ## | Considering row | 15 | column | 19 | value | 0.011 |
| ## | Considering row | 15 | column | 51 | value | 0.056 |
| ## | Considering row | 15 | column | 43 | value | 0.109 |
| ## | Considering row | 15 | column | 32 | value | 0.003 |
| ## | Considering row | 15 | column | 46 | value | 0.03 |
| ## | Considering row | 15 | column | 45 | value | 0.023 |
| ## | Considering row | 15 | column | 31 | value | 0.015 |
| ## | Considering row | 15 | column | 33 | value | 0.001 |
| ## | Considering row | 15 | column | 18 | value | 0.018 |
| ## | Considering row | 19 | column | 51 | value | 0.154 |
| ## | Considering row | 19 | column | 43 | value | 0.058 |
| ## | Considering row | 19 | column | 32 | value | 0.005 |
| ## | Considering row | 19 | column | 46 | value | 0.009 |
| ## | Considering row | 19 | column | 45 | value | 0.005 |
| ## | Considering row | 19 | column | 31 | value | 0.016 |
| ## | Considering row | 19 | column | 33 | value | 0.001 |
| ## | Considering row | 19 | column | 18 | value | 0.918 |
| ## | Flagging column | | 19 | | | |
| ## | Considering row | 51 | column | 43 | value | 0.136 |
| ## | Considering row | 51 | column | 32 | value | 0.058 |
| ## | Considering row | 51 | column | 46 | value | 0.017 |
| ## | Considering row | 51 | column | 45 | value | 0.007 |
| ## | Considering row | 51 | column | 31 | value | 0.008 |
| ## | Considering row | 51 | column | 33 | value | 0.007 |
| ## | Considering row | 51 | column | 18 | value | 0.164 |
| ## | Considering row | 43 | column | 32 | value | 0.002 |
| ## | Considering row | 43 | column | 46 | value | 0.09 |
| ## | Considering row | 43 | column | 45 | value | 0.046 |
| ## | Considering row | 43 | column | 31 | value | 0.054 |
| ## | Considering row | 43 | column | 33 | value | 0.054 |
| ## | Considering row | 43 | column | 18 | value | 0.046 |
| ## | Considering row | 32 | column | 46 | value | 0.589 |
| ## | Considering row | 32 | column | 45 | value | 0.501 |
| ## | Considering row | 32 | column | 31 | value | 0.683 |

```
## Considering row 32 column 33 value 0.623
## Considering row 32 column 18 value 0.004
## Considering row 46 column 45 value 0.846
## Flagging column 46
## Considering row 45 column 31 value 0.71
## Flagging column 45
## Considering row 31 column 33 value 0.979
## Flagging column 31
## Considering row 33 column 18 value 0.002
```

```
#this removes highly correlated variables (in psychometric theory .7+ correlation is a high correlation)
clean_training <- clean_training[, -removehighcorrelation]
```

```
for(i in c(8:ncol(clean_training)-1)) {clean_training[,i] = as.numeric(as.character(clean_training[,i]))}

for(i in c(8:ncol(testing_data)-1)) {testing_data[,i] = as.numeric(as.character(testing_data[,i]))}
```

The cleaned dataset will only consist of complete columns. For a lighter dataset, user name, timestamps and windows will be removed.

```
#drop blank column
featureset <- colnames(clean_training[colSums(is.na(clean_training)) == 0])[-(1:7)]
modeldata <- clean_training[featureset]

#cleansed data to build model
featureset
```

```
## [1] "yaw_arm" "total_accel_arm" "gyros_arm_x"
## [4] "gyros_arm_z" "magnet_arm_x" "magnet_arm_z"
## [7] "roll_dumbbell" "pitch_dumbbell" "yaw_dumbbell"
## [10] "total_accel_dumbbell" "gyros_dumbbell_y" "gyros_dumbbell_z"
## [13] "magnet_dumbbell_z" "roll_forearm" "pitch_forearm"
## [16] "yaw_forearm" "total_accel_forearm" "gyros_forearm_x"
## [19] "accel_forearm_x" "accel_forearm_z" "magnet_forearm_x"
## [22] "magnet_forearm_y" "magnet_forearm_z" "classe"
```

Cross-Validation

Split the sample in two samples. This is to divide training and testing for cross-validation.


```
idx <- createDataPartition(modeldata$classe, p=0.6, list=FALSE )
training <- modeldata[idx,]
testing <- modeldata[-idx,]

control <- trainControl(method="cv", 5)
model <- train(classe ~ ., data=training, method="rf", trControl=control, ntree=250)
model
```

```
## Random Forest
##
## 11776 samples
##    23 predictor
##    5 classes: 'A', 'B', 'C', 'D', 'E'
##
## No pre-processing
## Resampling: Cross-Validated (5 fold)
##
## Summary of sample sizes: 9422, 9422, 9420, 9420, 9420
##
## Resampling results across tuning parameters:
##
##    mtry  Accuracy   Kappa      Accuracy SD   Kappa SD
##    2     0.9692587  0.9610973  0.005571039   0.007049982
##   12     0.9658633  0.9568081  0.004786709   0.006057593
##   23     0.9538906  0.9416679  0.006806253   0.008613217
##
## Accuracy was used to select the optimal model using  the largest value.
## The final value used for the model was mtry = 2.
```

```
predict <- predict(model, testing)
confusionMatrix(testing$classe, predict)
```

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]


```
pml_write_files = function(x){  
  n = length(x)  
  for(i in 1:n){  
    filename = paste0("problem_id_",i,".txt")  
    write.table(x[i],file=filename,quote=FALSE,row.names=FALSE,col.names=FALSE)  
  }  
}  
  
x <- evaluation_data  
x <- x[feature_set[feature_set!='classe']]  
answers <- predict(rf, newdata=x)  
  
answers  
  
pml_write_files(answers)
```