Data622_HW1

Daniel Sullivan

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```
## Loading required package: ggplot2

## Warning: package 'ggplot2' was built under R version 4.2.2

## Loading required package: lattice

## -- Attaching packages --------------------------------------- tidyverse 1.3.2 --
## v tibble  3.1.8      v dplyr   1.0.10
## v tidyr   1.2.1      v stringr 1.4.1
## v readr   2.1.3      v forcats 0.5.2
## v purrr   0.3.5

## Warning: package 'readr' was built under R version 4.2.2

## Warning: package 'purrr' was built under R version 4.2.2

## -- Conflicts ------------------------------------------ tidyverse_conflicts() --
## x dplyr::filter() masks stats::filter()
## x dplyr::lag()    masks stats::lag()
## x purrr::lift()   masks caret::lift()
## corrplot 0.92 loaded
##
##
## Attaching package: 'gridExtra'
##
##
## The following object is masked from 'package:dplyr':
##
##     combine

## Warning: package 'xgboost' was built under R version 4.2.2

##
## Attaching package: 'xgboost'
##
## The following object is masked from 'package:dplyr':
##
##     slice

## Warning: package 'GGally' was built under R version 4.2.2
```

```
## Registered S3 method overwritten by 'GGally':
##   method from
##   +.gg   ggplot2

## Warning: package 'e1071' was built under R version 4.2.2

## Warning: package 'caTools' was built under R version 4.2.2

## Warning: package 'class' was built under R version 4.2.2

##
## Attaching package: 'reshape2'
##
## The following object is masked from 'package:tidyr':
##
##     smiths

## Warning: package 'randomForest' was built under R version 4.2.3

## randomForest 4.7-1.1
## Type rfNews() to see new features/changes/bug fixes.
##
## Attaching package: 'randomForest'
##
## The following object is masked from 'package:gridExtra':
##
##     combine
##
## The following object is masked from 'package:dplyr':
##
##     combine
##
## The following object is masked from 'package:ggplot2':
##
##     margin
```

First data set, from Kaggle on air quality in north Carolina

Data exploration

begin by loading the data and modifiying date time column so it is a bit easier to work with. then get data summaries

```
air_q=read.csv("https://raw.githubusercontent.com/TheSaltyCrab/Data-622/main/air-quality.csv")
air_q$Last_Check<-as.POSIXlt(air_q$Last_Check,format="%Y/%m/%d %H:%M:%S",tz=Sys.timezone())
air_q$Week_Day<-as.numeric(air_q$Last_Check$wday)
air_q$month<-as.numeric(air_q$Last_Check$mon)
air_q$hour<-as.numeric(air_q$Last_Check$hour)
air_q$Last_Check<-as.POSIXct(air_q$Last_Check,format="%Y/%m/%d %H:%M:%S",tz=Sys.timezone())

air_q<-air_q %>%
  select(!c(X,Y,Site_Label,Inside_Outside,ObjectId))
summary(air_q)
```

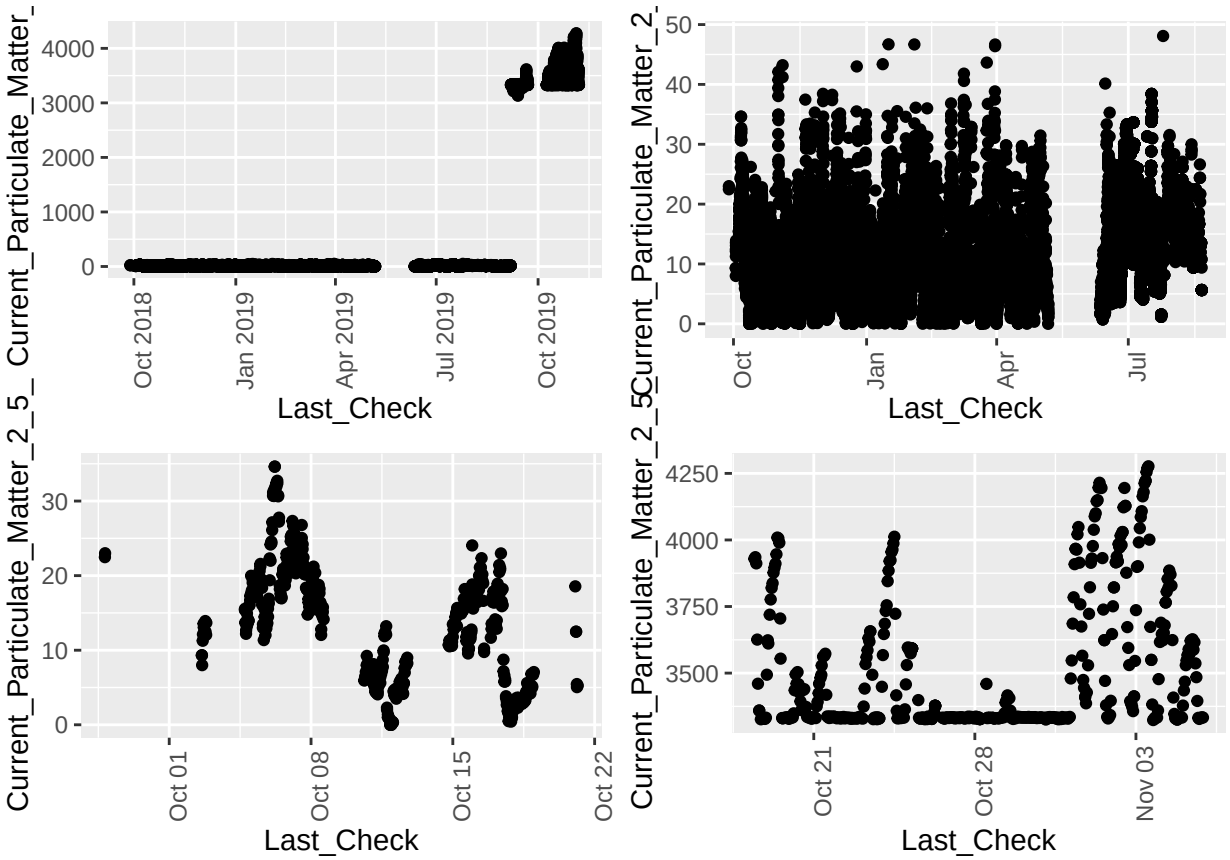
```
##    Last_Check                     Current_Particulate_Matter_2_5_
##  Min.   :2018-09-27 19:48:03.00   Min.   :   0.00
##  1st Qu.:2019-01-01 09:48:45.50   1st Qu.:   6.91
##  Median :2019-06-12 06:34:01.00   Median :  13.03
##  Mean   :2019-04-19 03:27:07.95   Mean   : 313.21
##  3rd Qu.:2019-07-14 07:46:09.00   3rd Qu.:  20.85
##  Max.   :2019-11-06 20:54:27.00   Max.   :4276.67
##  NA's   :1
##  PM_2_5_10_Minute_Avg_ PM_2_5_30_Minute_Avg_ PM_2_5_1_Hour_Avg_
##  Min.   : 0.00         Min.   : 0.02         Min.   : 0.06
##  1st Qu.: 7.11         1st Qu.: 7.21         1st Qu.: 7.51
##  Median :12.48         Median :12.34         Median :11.95
##  Mean   :12.88         Mean   :12.90         Mean   :12.89
##  3rd Qu.:17.65         3rd Qu.:17.59         3rd Qu.:17.56
##  Max.   :45.13         Max.   :41.72         Max.   :39.43
##
##  PM_2_5_6_Hour_Avg_ PM_2_5_24_Hour_Avg_ PM_2_5_One_Week_Avg_    Temp__F_
##  Min.   : 0.46      Min.   : 3.18       Min.   : 8.13        Min.   : 23.00
##  1st Qu.: 8.77      1st Qu.: 9.53       1st Qu.:10.77        1st Qu.: 59.00
##  Median :12.12      Median :14.48       Median :14.13        Median : 77.00
##  Mean   :13.03      Mean   :13.16       Mean   :12.94        Mean   : 74.93
##  3rd Qu.:18.12      3rd Qu.:15.99       3rd Qu.:14.86        3rd Qu.: 89.00
##  Max.   :34.73      Max.   :26.90       Max.   :16.08        Max.   :110.00
##
##   Humidity____   Pressure__mbar_    Latitude       Longitude
##  Min.   :12.00   Min.   : 977    Min.   :35.93   Min.   :-79.04
##  1st Qu.:38.00   1st Qu.:1001    1st Qu.:35.93   1st Qu.:-79.04
##  Median :51.00   Median :1005    Median :35.93   Median :-79.04
##  Mean   :49.45   Mean   :1005    Mean   :35.93   Mean   :-79.04
##  3rd Qu.:61.00   3rd Qu.:1009    3rd Qu.:35.93   3rd Qu.:-79.04
##  Max.   :82.00   Max.   :1028    Max.   :35.93   Max.   :-79.04
##
##  Uptime__Seconds_ RSSI__WiFi_signal_strength_dBm_ Hardware_Issues
##  Min.   :    20   Min.   :-96.00                  Min.   :   0.0
##  1st Qu.:  1320   1st Qu.:-84.00                  1st Qu.:   1.0
##  Median :  3790   Median :-82.00                  Median :  10.0
##  Mean   : 11578   Mean   :-79.86                  Mean   : 108.2
##  3rd Qu.: 13940   3rd Qu.:-80.00                  3rd Qu.:  89.0
##  Max.   :164737   Max.   : 31.00                  Max.   :2413.0
##                                                   NA's   :6228
##  Age_of_Data_at_Check__minutes_    Week_Day         month
##  Min.   :  0.000                Min.   :0.000   Min.   : 0.000
##  1st Qu.:  0.000                1st Qu.:1.000   1st Qu.: 5.000
##  Median :  0.000                Median :3.000   Median : 6.000
##  Mean   :  1.388                Mean   :3.026   Mean   : 6.078
##  3rd Qu.:  1.000                3rd Qu.:5.000   3rd Qu.: 9.000
##  Max.   :144.000                Max.   :6.000   Max.   :11.000
##  NA's   :6261
##       hour
##  Min.   : 0.00
##  1st Qu.: 6.00
##  Median :12.00
##  Mean   :11.94
##  3rd Qu.:18.00
```

```
##  Max.   :23.00
##
```

these below chunks show the plots of the various ppm readings/averages and targets some interesting features that were noticed.

```
#air_q$Week_Day<-air_q$Last_Check$wday
#air_q$Last_Check
#library(scales)
#head(air_q,1000)
a1=ggplot(air_q, aes(Last_Check, Current_Particulate_Matter_2_5_)) +
       geom_point() +
       theme(axis.text.x = element_text(angle = 90, hjust = 1))

b1=ggplot(head(air_q,11000), aes(Last_Check, Current_Particulate_Matter_2_5_)) +
       geom_point() +
       theme(axis.text.x = element_text(angle = 90, hjust = 1))
c1=ggplot(head(air_q,500), aes(Last_Check, Current_Particulate_Matter_2_5_)) +
       geom_point() +
       theme(axis.text.x = element_text(angle = 90, hjust = 1))
d1=ggplot(tail(air_q,489), aes(Last_Check, Current_Particulate_Matter_2_5_)) +
       geom_point() +
       theme(axis.text.x = element_text(angle = 90, hjust = 1))

grid.arrange(a1,b1,c1,d1)
```

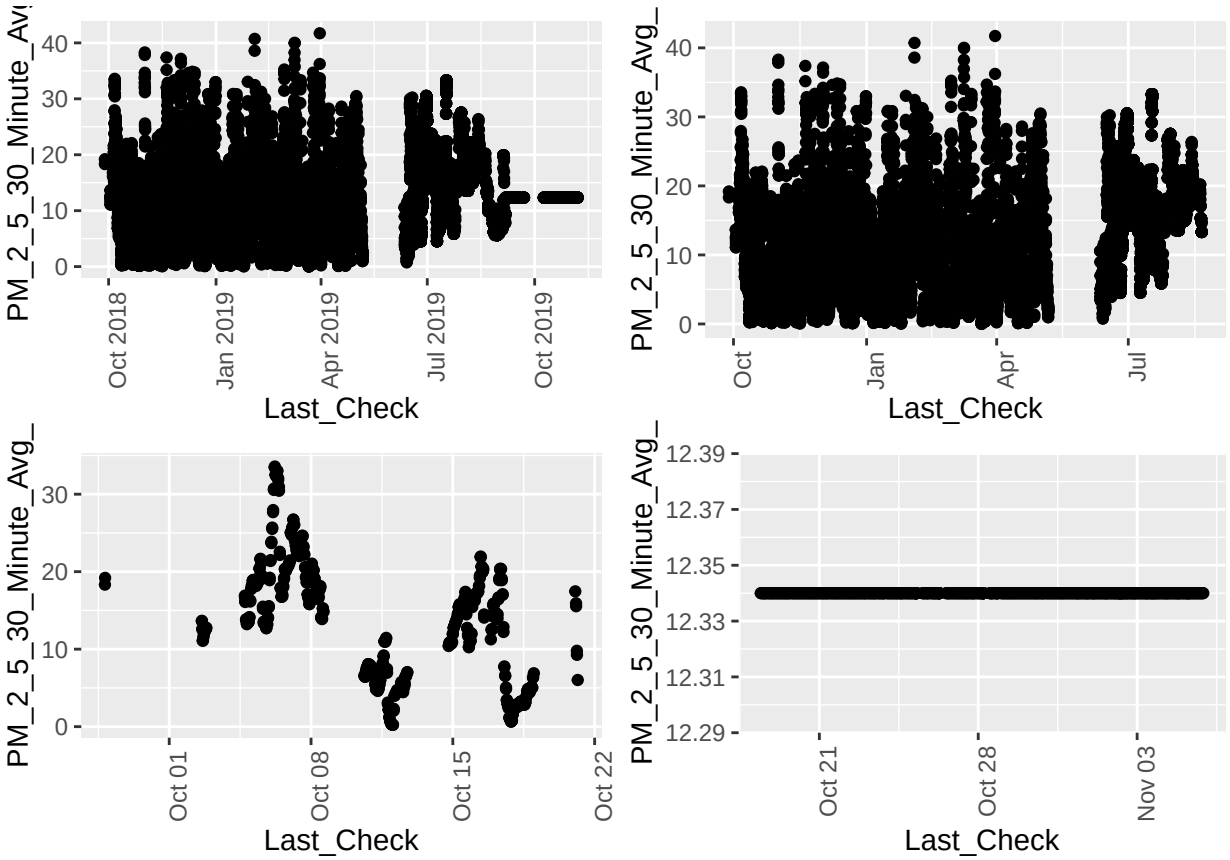
```
## Warning: Removed 1 rows containing missing values (‘geom_point()‘).
## Removed 1 rows containing missing values (‘geom_point()‘).
```




```
      #scale_x_datetime(labels = date_format("%H:%M:%S"))
#air_q$Last_Check[1]
```

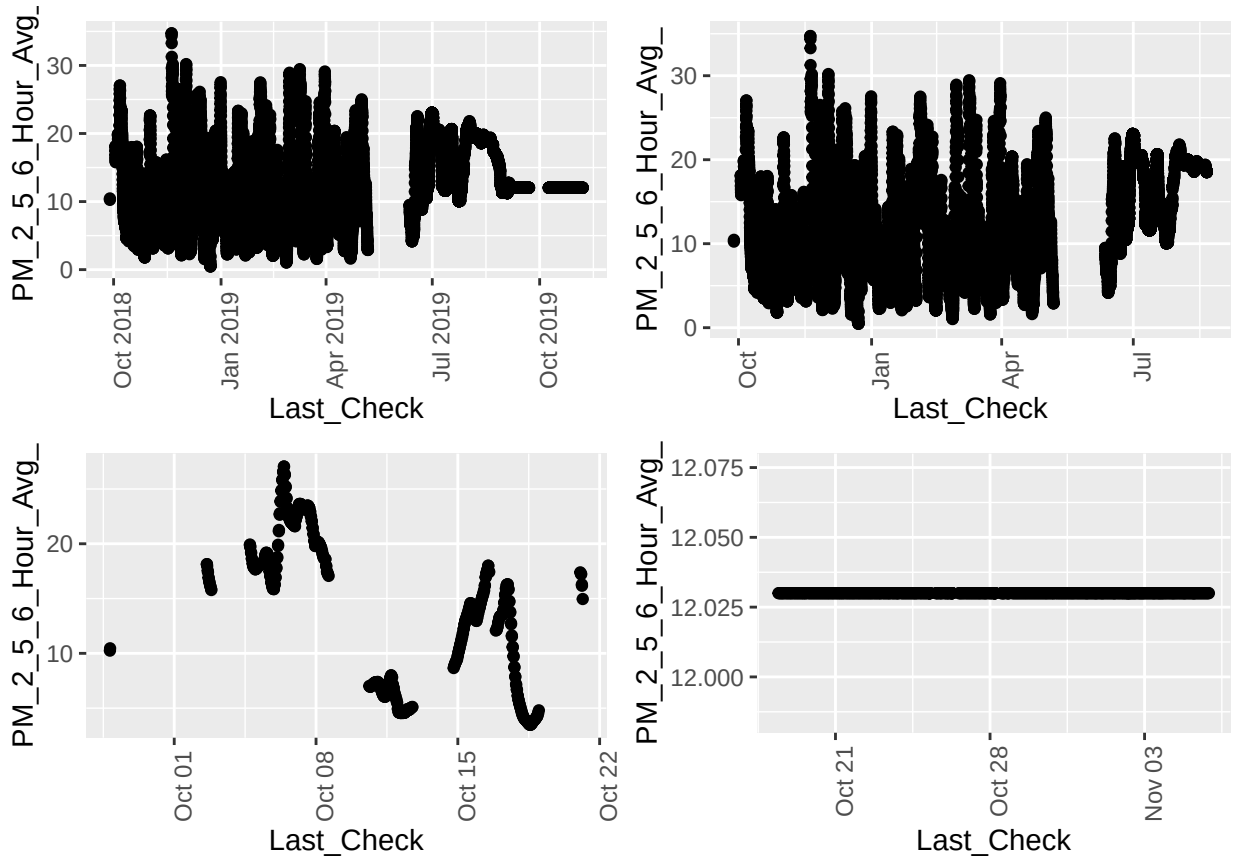
```
a2=ggplot(air_q, aes(Last_Check, PM_2_5_30_Minute_Avg_)) +
      geom_point() +
      theme(axis.text.x = element_text(angle = 90, hjust = 1))

b2=ggplot(head(air_q,11000), aes(Last_Check, PM_2_5_30_Minute_Avg_)) +
      geom_point() +
      theme(axis.text.x = element_text(angle = 90, hjust = 1))
c2=ggplot(head(air_q,500), aes(Last_Check, PM_2_5_30_Minute_Avg_)) +
      geom_point() +
      theme(axis.text.x = element_text(angle = 90, hjust = 1))
d2=ggplot(tail(air_q,489), aes(Last_Check, PM_2_5_30_Minute_Avg_)) +
      geom_point() +
      theme(axis.text.x = element_text(angle = 90, hjust = 1))

grid.arrange(a2,b2,c2,d2)
```

```
## Warning: Removed 1 rows containing missing values (‘geom_point()‘).
## Removed 1 rows containing missing values (‘geom_point()‘).
```



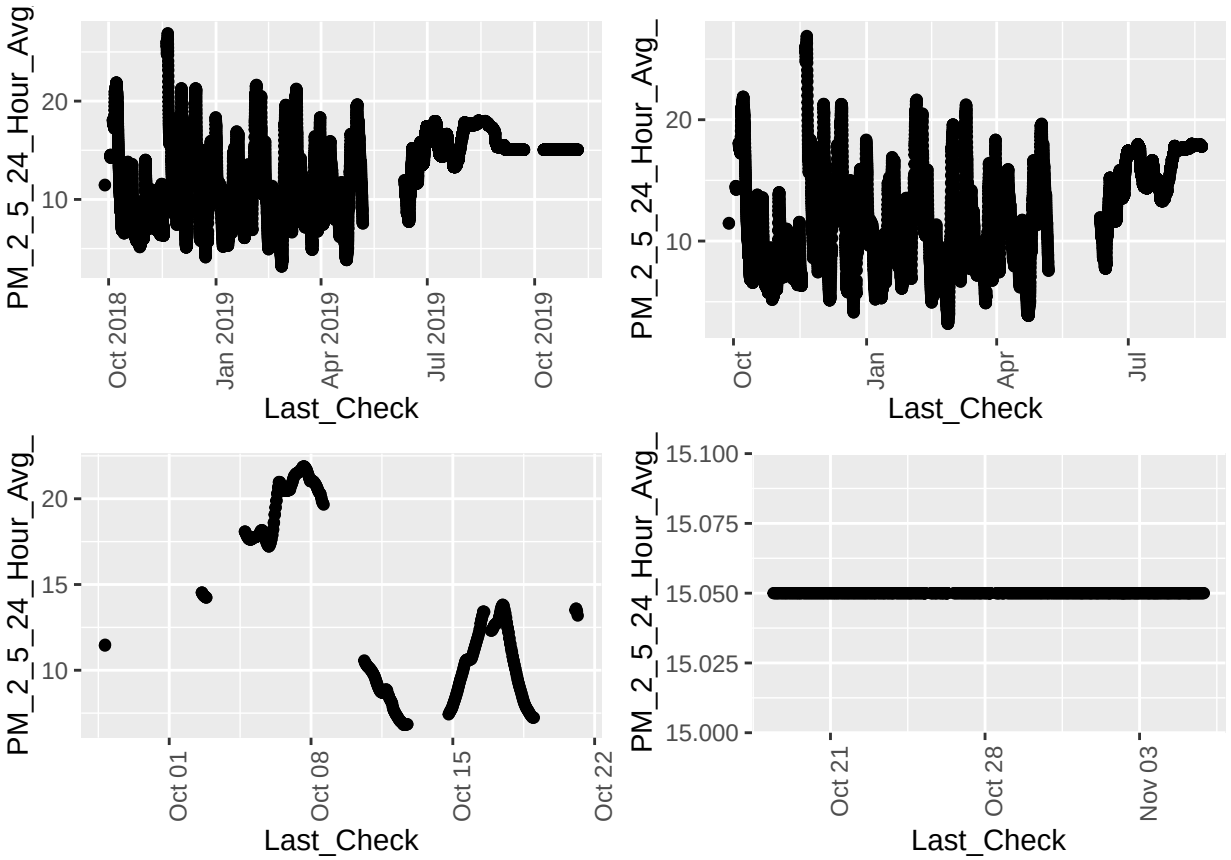

```
a3=ggplot(air_q, aes(Last_Check, PM_2_5_6_Hour_Avg_)) +
       geom_point() +
       theme(axis.text.x = element_text(angle = 90, hjust = 1))

b3=ggplot(head(air_q,11000), aes(Last_Check, PM_2_5_6_Hour_Avg_)) +
       geom_point() +
       theme(axis.text.x = element_text(angle = 90, hjust = 1))
c3=ggplot(head(air_q,500), aes(Last_Check, PM_2_5_6_Hour_Avg_)) +
       geom_point() +
       theme(axis.text.x = element_text(angle = 90, hjust = 1))
d3=ggplot(tail(air_q,489), aes(Last_Check, PM_2_5_6_Hour_Avg_)) +
       geom_point() +
       theme(axis.text.x = element_text(angle = 90, hjust = 1))

grid.arrange(a3,b3,c3,d3)
```

```
## Warning: Removed 1 rows containing missing values (‘geom_point()‘).
## Removed 1 rows containing missing values (‘geom_point()‘).
```

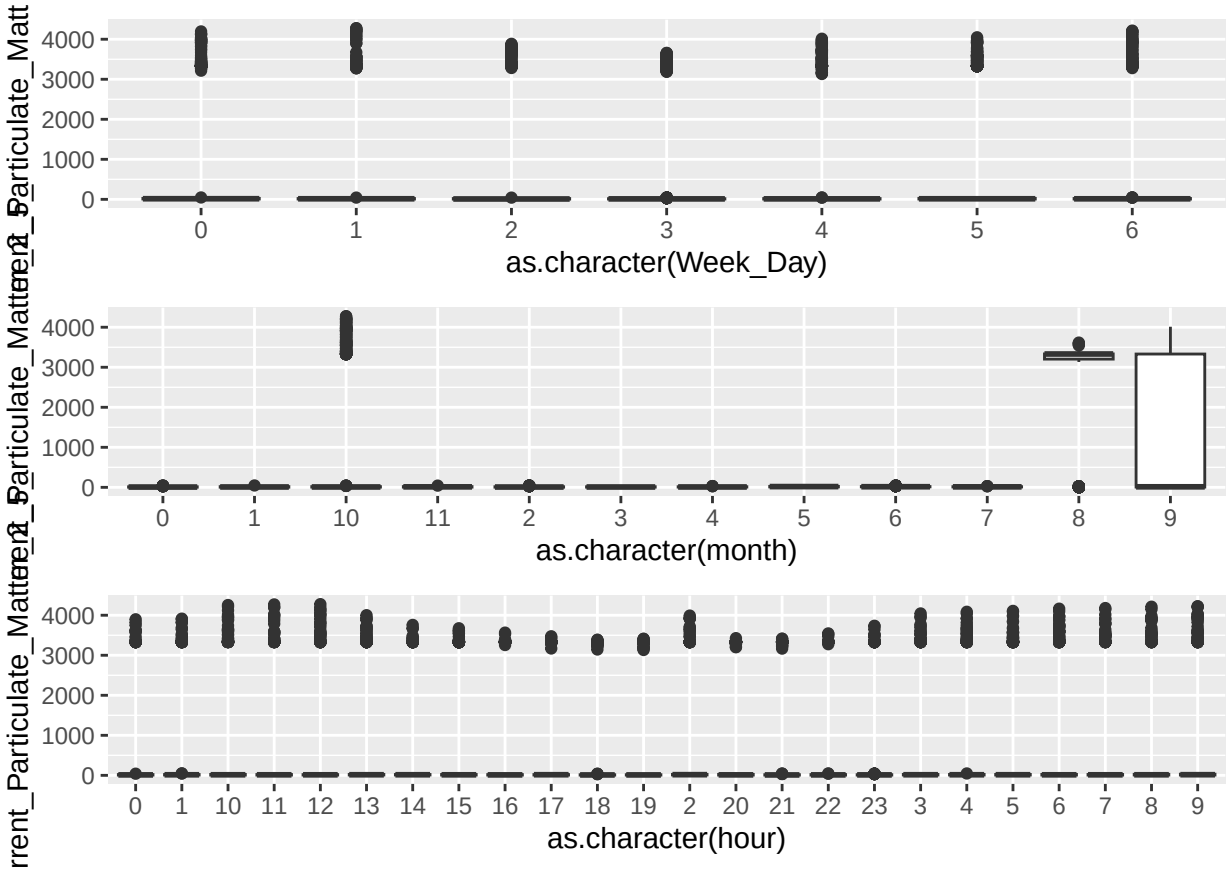



```
a4=ggplot(air_q, aes(Last_Check, PM_2_5_24_Hour_Avg_)) +
       geom_point() +
       theme(axis.text.x = element_text(angle = 90, hjust = 1))

b4=ggplot(head(air_q,11000), aes(Last_Check, PM_2_5_24_Hour_Avg_)) +
       geom_point() +
       theme(axis.text.x = element_text(angle = 90, hjust = 1))
c4=ggplot(head(air_q,500), aes(Last_Check, PM_2_5_24_Hour_Avg_)) +
       geom_point() +
       theme(axis.text.x = element_text(angle = 90, hjust = 1))
d4=ggplot(tail(air_q,489), aes(Last_Check, PM_2_5_24_Hour_Avg_)) +
       geom_point() +
       theme(axis.text.x = element_text(angle = 90, hjust = 1))

grid.arrange(a4,b4,c4,d4)
```

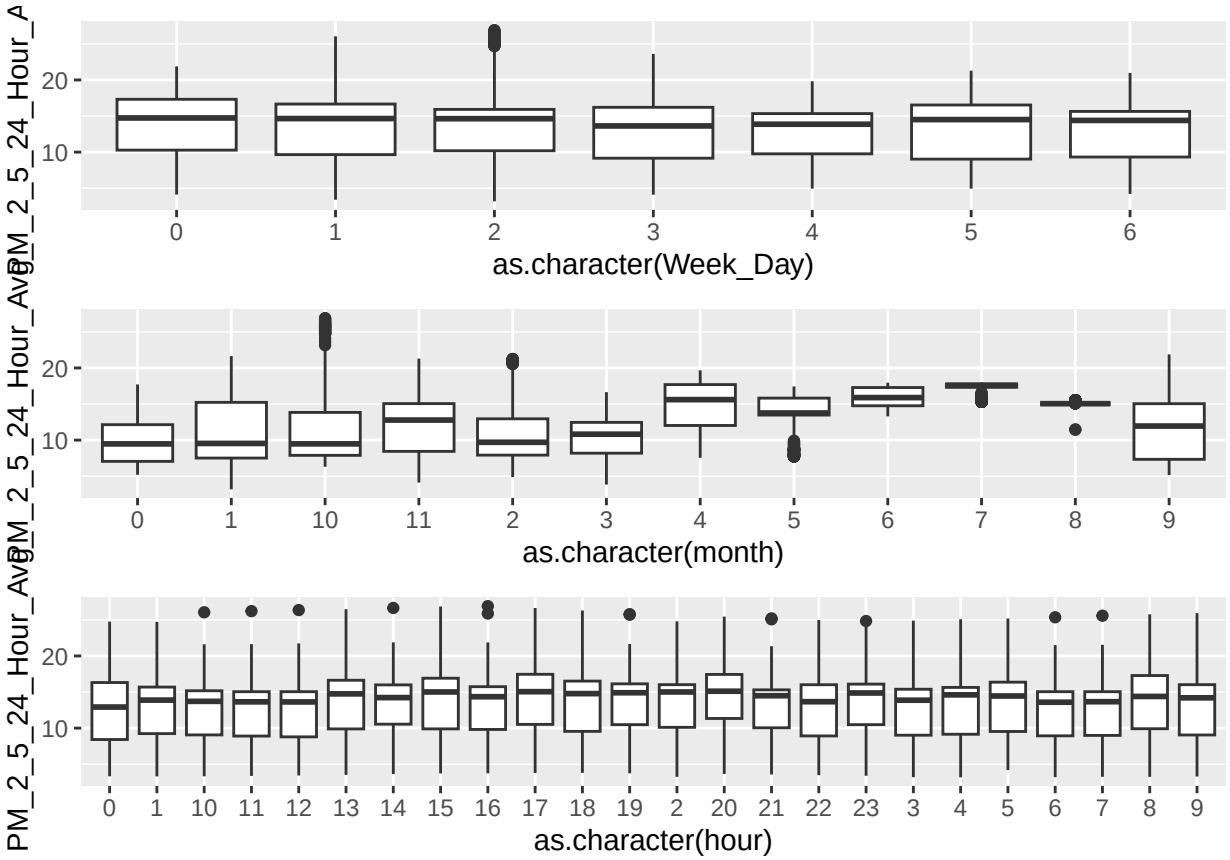
```
## Warning: Removed 1 rows containing missing values (‘geom_point()‘).
## Removed 1 rows containing missing values (‘geom_point()‘).
```



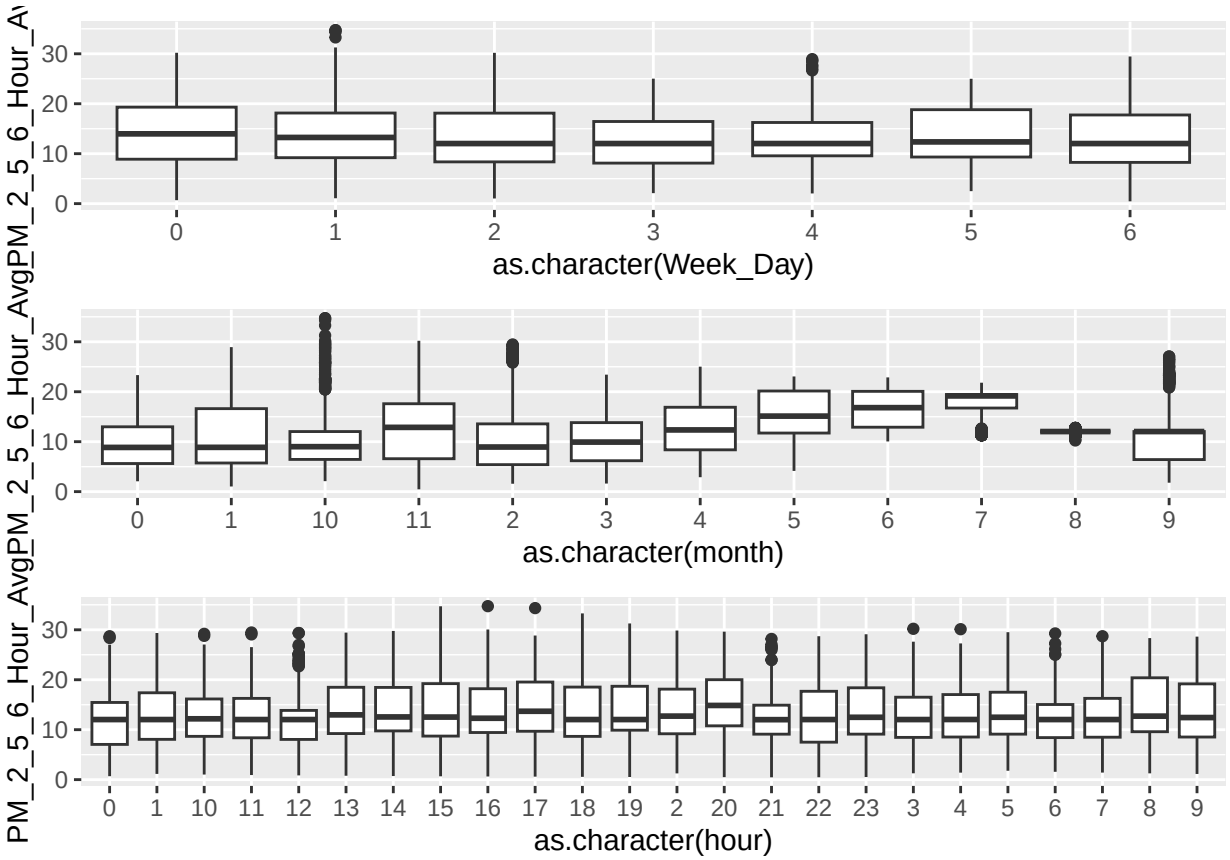

```
a7<-ggplot(air_q, aes(x=as.character(Week_Day), y=Current_Particulate_Matter_2_5_), group=) +
  geom_boxplot()
b7=ggplot(air_q, aes(x=as.character(month), y=Current_Particulate_Matter_2_5_), group=) +
  geom_boxplot()
c7=ggplot(air_q, aes(x=as.character(hour), y=Current_Particulate_Matter_2_5_), group=) +
  geom_boxplot()
grid.arrange(a7,b7,c7)
```



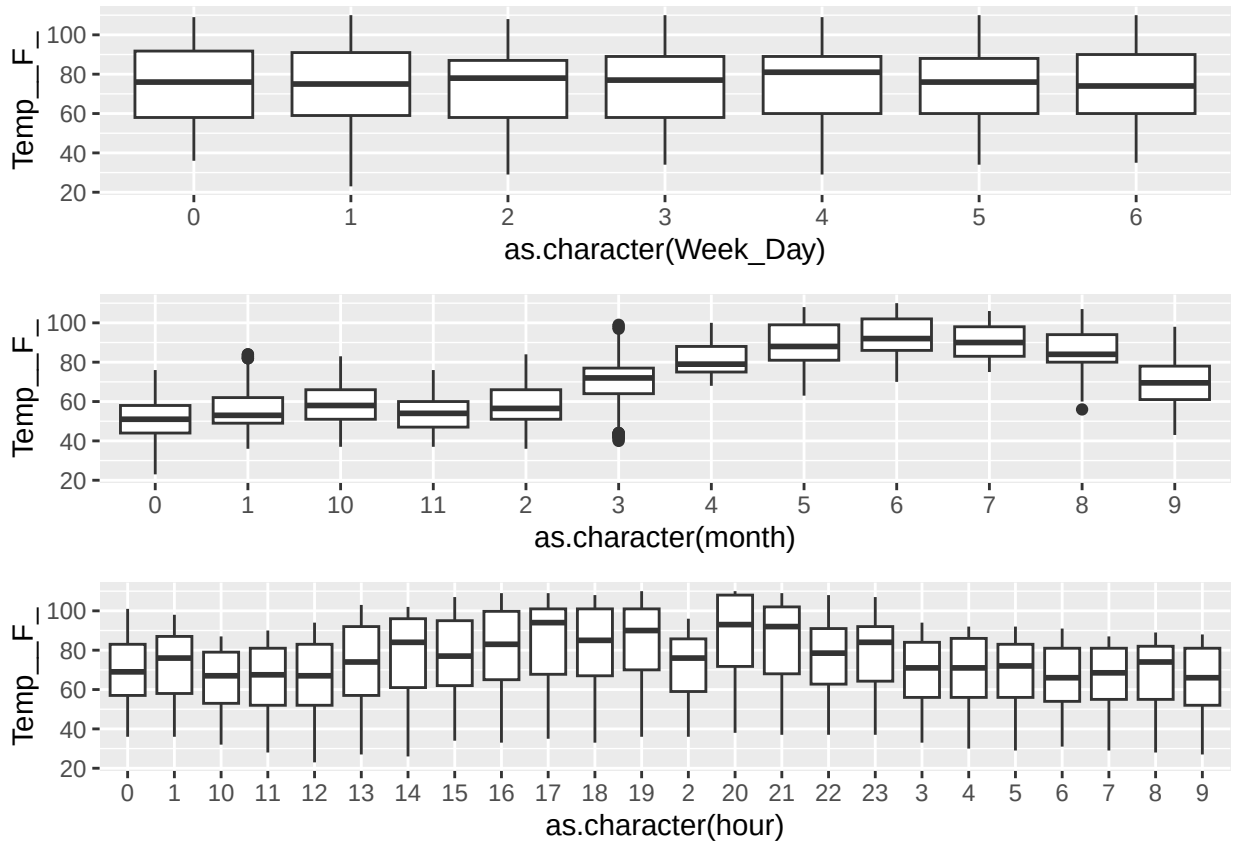

```
#ggplot(air_q, aes(x=as.character(Week_Day), y=PM_2_5_24_Hour_Avg_)) +
#  geom_boxplot()
a5=ggplot(air_q, aes(x=as.character(Week_Day), y=PM_2_5_24_Hour_Avg_)) +
  geom_boxplot()
b5=ggplot(air_q, aes(x=as.character(month), y=PM_2_5_24_Hour_Avg_)) +
  geom_boxplot()
c5=ggplot(air_q, aes(x=as.character(hour), y=PM_2_5_24_Hour_Avg_), group=) +
  geom_boxplot()

grid.arrange(a5,b5,c5)
```




```
#ggplot(air_q, aes(x=as.character(Week_Day), y=PM_2_5_24_Hour_Avg_)) +
#  geom_boxplot()
a6=ggplot(air_q, aes(x=as.character(Week_Day), y=PM_2_5_6_Hour_Avg_)) +
  geom_boxplot()
b6=ggplot(air_q, aes(x=as.character(month), y=PM_2_5_6_Hour_Avg_), group=) +
  geom_boxplot()
c6=ggplot(air_q, aes(x=as.character(hour), y=PM_2_5_6_Hour_Avg_), group=) +
  geom_boxplot()

grid.arrange(a6,b6,c6)
```




```
#ggplot(air_q, aes(x=as.character(Week_Day), y=PM_2_5_24_Hour_Avg_)) +
#  geom_boxplot()
a8=ggplot(air_q, aes(x=as.character(Week_Day), y=Temp__F_)) +
  geom_boxplot()
b8=ggplot(air_q, aes(x=as.character(month), y=Temp__F_), group=) +
  geom_boxplot()
c8=ggplot(air_q, aes(x=as.character(hour), y=Temp__F_), group=) +
  geom_boxplot()

grid.arrange(a8,b8,c8)
```

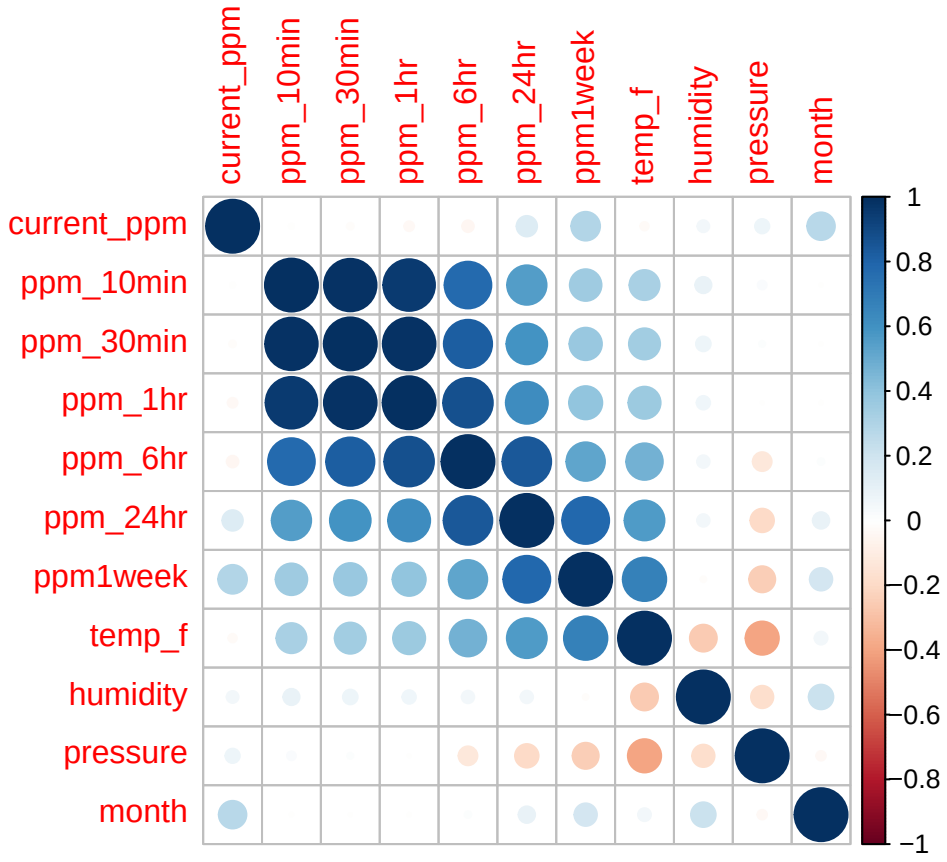


correlation matrix for each data point after cleaning the data frame.

```
modeling_df<-air_q %>%
  select(!c(Week_Day,hour,Latitude,Longitude,Age_of_Data_at_Check__minutes_,Last_Check,Hardware_Issues,
summary(modeling_df)
```

```
##  Current_Particulate_Matter_2_5_ PM_2_5_10_Minute_Avg_ PM_2_5_30_Minute_Avg_
##  Min.   :   0.00                 Min.   : 0.00         Min.   : 0.02
##  1st Qu.:   6.91                 1st Qu.: 7.11         1st Qu.: 7.21
##  Median :  13.03                 Median :12.48         Median :12.34
##  Mean   : 313.21                 Mean   :12.88         Mean   :12.90
##  3rd Qu.:  20.85                 3rd Qu.:17.65         3rd Qu.:17.59
##  Max.   :4276.67                 Max.   :45.13         Max.   :41.72
##  PM_2_5_1_Hour_Avg_ PM_2_5_6_Hour_Avg_ PM_2_5_24_Hour_Avg_ PM_2_5_One_Week_Avg_
##  Min.   : 0.06      Min.   : 0.46      Min.   : 3.18       Min.   : 8.13
##  1st Qu.: 7.51      1st Qu.: 8.77      1st Qu.: 9.53       1st Qu.:10.77
##  Median :11.95      Median :12.12      Median :14.48       Median :14.13
##  Mean   :12.89      Mean   :13.03      Mean   :13.16       Mean   :12.94
##  3rd Qu.:17.56      3rd Qu.:18.12      3rd Qu.:15.99       3rd Qu.:14.86
##  Max.   :39.43      Max.   :34.73      Max.   :26.90       Max.   :16.08
##     Temp__F_       Humidity____   Pressure__mbar_     month
##  Min.   : 23.00   Min.   :12.00   Min.   : 977    Min.   : 0.000
##  1st Qu.: 59.00   1st Qu.:38.00   1st Qu.:1001    1st Qu.: 5.000
##  Median : 77.00   Median :51.00   Median :1005    Median : 6.000
##  Mean   : 74.93   Mean   :49.45   Mean   :1005    Mean   : 6.078
##  3rd Qu.: 89.00   3rd Qu.:61.00   3rd Qu.:1009    3rd Qu.: 9.000
##  Max.   :110.00   Max.   :82.00   Max.   :1028    Max.   :11.000
```

```
#ggpairs(modeling_df)
colnames(modeling_df)<-c('current_ppm','ppm_10min','ppm_30min','ppm_1hr','ppm_6hr','ppm_24hr','ppm1week

corrplot(cor(modeling_df))
```



partitioning data for train and test subsets.

```
set.seed(9)
x = createDataPartition(modeling_df$month, p = .8, list = F)
train_air = modeling_df[x, ]
test_air = modeling_df[-x, ]
train_air_x = data.matrix(train_air[, -11])
train_air_y = train_air[,11]
test_air_x = data.matrix(test_air[, -11])
test_air_y = test_air[, 11]
xgb_train_air = xgb.DMatrix(data = train_air_x, label = train_air_y)
xgb_test_air = xgb.DMatrix(data = test_air_x, label = test_air_y)
```

Air Quality random forest model

```r
set.seed(9)
tree_model <- randomForest(
  formula = month ~ .,
  x=train_air_x,y=train_air_y, xtest = test_air_x, ytest = test_air_y
)

min<-which.min(tree_model$mse)
#train_air_x
tree_model_final <- randomForest(
  formula = month ~ .,
  data=train_air, ntree = min
)

#train_air$ppm_10min
```

```r
predictionT<-predict(tree_model_final, test_air_x)
#print(prediction)
predictionT<-round(predictionT,0)
#prediction1[]
#test_air$month[]
#test_air$month
cmT<-(confusionMatrix(data = factor(predictionT), reference = factor(test_air_y)))
cmT
```

```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction   0   1   2   3   4   5   6   7   8   9  10  11
##         0   29   0   0   0   0   0   0   0   0   0   0   0
##         1   66  24   1   0   0   0   0   0   0   0   0   0
##         2   45  52 107   6   0   0   0   0   0   0   0   2
##         3    5  34  26 135   0   0   0   0   0   0   0   1
##         4    7  12   8  18  20   0   0   0   0   0   0   0
##         5    1   2   7   4   7 264   0   0   0   0   1   4
##         6    1   3   1   0   1  16 573   0   1   1   1   5
##         7    0   1   1   0   0   0   0 142   0  10   6  10
##         8    0   1   0   0   0   0   0   0  75  67  10  16
##         9    0   1   0   0   0   0   0   0  16 316  68  32
##         10   0   0   0   0   0   0   0   0   0   0 154  70
##         11   0   0   0   0   0   0   0   0   0   0   0   9
##
## Overall Statistics
##
##                Accuracy : 0.7404
##                  95% CI : (0.7227, 0.7575)
##     No Information Rate : 0.2296
##     P-Value [Acc > NIR] : < 2.2e-16
##
##                   Kappa : 0.7035
##
##  Mcnemar's Test P-Value : NA
##
## Statistics by Class:
```

```
##
##                      Class: 0 Class: 1 Class: 2 Class: 3 Class: 4 Class: 5
## Sensitivity           0.18831 0.184615  0.70861  0.82822 0.714286   0.9429
## Specificity           1.00000 0.971682  0.95522  0.97171 0.981767   0.9883
## Pos Pred Value        1.00000 0.263736  0.50472  0.67164 0.307692   0.9103
## Neg Pred Value        0.94933 0.955925  0.98074  0.98780 0.996709   0.9927
## Prevalence            0.06170 0.052083  0.06050  0.06530 0.011218   0.1122
## Detection Rate        0.01162 0.009615  0.04287  0.05409 0.008013   0.1058
## Detection Prevalence  0.01162 0.036458  0.08494  0.08053 0.026042   0.1162
## Balanced Accuracy     0.59416 0.578149  0.83192  0.89997 0.848026   0.9656
##                      Class: 6 Class: 7 Class: 8 Class: 9 Class: 10 Class: 11
## Sensitivity            1.0000  1.00000  0.81522   0.8020   0.64167  0.060403
## Specificity            0.9844  0.98811  0.96090   0.9443   0.96897  1.000000
## Pos Pred Value         0.9502  0.83529  0.44379   0.7298   0.68750  1.000000
## Neg Pred Value         1.0000  1.00000  0.99269   0.9622   0.96215  0.943707
## Prevalence             0.2296  0.05689  0.03686   0.1579   0.09615  0.059696
## Detection Rate         0.2296  0.05689  0.03005   0.1266   0.06170  0.003606
## Detection Prevalence   0.2416  0.06811  0.06771   0.1735   0.08974  0.003606
## Balanced Accuracy      0.9922  0.99405  0.88806   0.8732   0.80532  0.530201
```

Air quality XGboost model

I modified some of the code from this article to guide me through XGboosting: https://www.statology.org/xgboost-in-r/

```
## [1]  train-rmse:4.834753 test-rmse:4.849645
## [2]  train-rmse:3.785242 test-rmse:3.804412
## [3]  train-rmse:3.166469 test-rmse:3.197186
## [4]  train-rmse:2.799040 test-rmse:2.829624
## [5]  train-rmse:2.603811 test-rmse:2.636483
## [6]  train-rmse:2.422776 test-rmse:2.460411
## [7]  train-rmse:2.323145 test-rmse:2.359675
## [8]  train-rmse:2.282854 test-rmse:2.325424
## [9]  train-rmse:2.255568 test-rmse:2.297541
## [10] train-rmse:2.221585 test-rmse:2.269608
## [11] train-rmse:2.167594 test-rmse:2.220385
## [12] train-rmse:2.123513 test-rmse:2.181532
## [13] train-rmse:2.103189 test-rmse:2.164105
## [14] train-rmse:2.084414 test-rmse:2.153603
## [15] train-rmse:2.074129 test-rmse:2.146784
## [16] train-rmse:2.042023 test-rmse:2.121005
## [17] train-rmse:2.030957 test-rmse:2.116781
## [18] train-rmse:2.013365 test-rmse:2.097418
## [19] train-rmse:1.989379 test-rmse:2.080314
## [20] train-rmse:1.973318 test-rmse:2.068823
## [21] train-rmse:1.962661 test-rmse:2.061162
## [22] train-rmse:1.954086 test-rmse:2.056326
## [23] train-rmse:1.931481 test-rmse:2.038819
## [24] train-rmse:1.925251 test-rmse:2.033167
## [25] train-rmse:1.914220 test-rmse:2.026370
## [26] train-rmse:1.893959 test-rmse:2.012701
## [27] train-rmse:1.877462 test-rmse:2.002424
## [28] train-rmse:1.863680 test-rmse:1.990429
```

```
## [29] train-rmse:1.845876 test-rmse:1.975668
## [30] train-rmse:1.836742 test-rmse:1.970188
## [31] train-rmse:1.831813 test-rmse:1.967251
## [32] train-rmse:1.819597 test-rmse:1.957064
## [33] train-rmse:1.799478 test-rmse:1.939745
## [34] train-rmse:1.795169 test-rmse:1.938654
## [35] train-rmse:1.789770 test-rmse:1.935092
## [36] train-rmse:1.775975 test-rmse:1.922968
## [37] train-rmse:1.772734 test-rmse:1.922033
## [38] train-rmse:1.767721 test-rmse:1.920059
## [39] train-rmse:1.764882 test-rmse:1.918542
## [40] train-rmse:1.754454 test-rmse:1.910042
## [41] train-rmse:1.748314 test-rmse:1.902896
## [42] train-rmse:1.744831 test-rmse:1.901527
## [43] train-rmse:1.741492 test-rmse:1.900388
## [44] train-rmse:1.721366 test-rmse:1.885203
## [45] train-rmse:1.717342 test-rmse:1.882525
## [46] train-rmse:1.694710 test-rmse:1.860334
## [47] train-rmse:1.689307 test-rmse:1.856185
## [48] train-rmse:1.685734 test-rmse:1.852297
## [49] train-rmse:1.674017 test-rmse:1.846736
## [50] train-rmse:1.667884 test-rmse:1.843265
## [51] train-rmse:1.665411 test-rmse:1.842386
## [52] train-rmse:1.662956 test-rmse:1.840369
## [53] train-rmse:1.654507 test-rmse:1.833940
## [54] train-rmse:1.645006 test-rmse:1.829810
## [55] train-rmse:1.638262 test-rmse:1.819650
## [56] train-rmse:1.636534 test-rmse:1.818361
## [57] train-rmse:1.627987 test-rmse:1.811768
## [58] train-rmse:1.622852 test-rmse:1.807327
## [59] train-rmse:1.621637 test-rmse:1.806176
## [60] train-rmse:1.618647 test-rmse:1.803724
## [61] train-rmse:1.613447 test-rmse:1.799071
## [62] train-rmse:1.600116 test-rmse:1.782870
## [63] train-rmse:1.588636 test-rmse:1.772174
## [64] train-rmse:1.580257 test-rmse:1.764050
## [65] train-rmse:1.568717 test-rmse:1.753972
## [66] train-rmse:1.563812 test-rmse:1.749497
## [67] train-rmse:1.562438 test-rmse:1.749702
## [68] train-rmse:1.555240 test-rmse:1.746053
## [69] train-rmse:1.554559 test-rmse:1.745865
## [70] train-rmse:1.551845 test-rmse:1.743963
## [71] train-rmse:1.548801 test-rmse:1.742251
## [72] train-rmse:1.538518 test-rmse:1.737380
## [73] train-rmse:1.533762 test-rmse:1.735440
## [74] train-rmse:1.529667 test-rmse:1.734095
## [75] train-rmse:1.528249 test-rmse:1.734558
## [76] train-rmse:1.519121 test-rmse:1.730109
## [77] train-rmse:1.508616 test-rmse:1.724157
## [78] train-rmse:1.504589 test-rmse:1.721608
## [79] train-rmse:1.503239 test-rmse:1.721405
## [80] train-rmse:1.495719 test-rmse:1.722850
## [81] train-rmse:1.488913 test-rmse:1.716080
## [82] train-rmse:1.484064 test-rmse:1.712487
```

```
## [83] train-rmse:1.482721 test-rmse:1.712212
## [84] train-rmse:1.481232 test-rmse:1.710644
## [85] train-rmse:1.473901 test-rmse:1.710661
## [86] train-rmse:1.473347 test-rmse:1.710151
## [87] train-rmse:1.466688 test-rmse:1.704507
## [88] train-rmse:1.462466 test-rmse:1.703142
## [89] train-rmse:1.457765 test-rmse:1.703497
## [90] train-rmse:1.450236 test-rmse:1.696977
## [91] train-rmse:1.448026 test-rmse:1.695553
## [92] train-rmse:1.444946 test-rmse:1.693536
## [93] train-rmse:1.443047 test-rmse:1.691840
## [94] train-rmse:1.439013 test-rmse:1.687923
## [95] train-rmse:1.431740 test-rmse:1.680353
## [96] train-rmse:1.426961 test-rmse:1.679424
## [97] train-rmse:1.424505 test-rmse:1.678682
## [98] train-rmse:1.419496 test-rmse:1.675851
## [99] train-rmse:1.414407 test-rmse:1.673096
## [100]    train-rmse:1.412217 test-rmse:1.672809
## [101]    train-rmse:1.409500 test-rmse:1.671306
## [102]    train-rmse:1.407701 test-rmse:1.670519
## [103]    train-rmse:1.400505 test-rmse:1.665865
## [104]    train-rmse:1.395844 test-rmse:1.662993
## [105]    train-rmse:1.391700 test-rmse:1.664330
## [106]    train-rmse:1.389982 test-rmse:1.663397
## [107]    train-rmse:1.384239 test-rmse:1.658045
## [108]    train-rmse:1.382121 test-rmse:1.656563
## [109]    train-rmse:1.381143 test-rmse:1.655155
## [110]    train-rmse:1.378287 test-rmse:1.653035
## [111]    train-rmse:1.377026 test-rmse:1.652289
## [112]    train-rmse:1.370860 test-rmse:1.650304
## [113]    train-rmse:1.364412 test-rmse:1.646024
## [114]    train-rmse:1.358288 test-rmse:1.641028
## [115]    train-rmse:1.353328 test-rmse:1.637114
## [116]    train-rmse:1.350787 test-rmse:1.637903
## [117]    train-rmse:1.348779 test-rmse:1.635267
## [118]    train-rmse:1.347834 test-rmse:1.634400
## [119]    train-rmse:1.343954 test-rmse:1.632325
## [120]    train-rmse:1.342747 test-rmse:1.631873
## [121]    train-rmse:1.336884 test-rmse:1.631264
## [122]    train-rmse:1.335554 test-rmse:1.631084
## [123]    train-rmse:1.334292 test-rmse:1.629907
## [124]    train-rmse:1.332897 test-rmse:1.629227
## [125]    train-rmse:1.330864 test-rmse:1.627396
## [126]    train-rmse:1.329605 test-rmse:1.626103
## [127]    train-rmse:1.324230 test-rmse:1.621258
## [128]    train-rmse:1.323127 test-rmse:1.620461
## [129]    train-rmse:1.322719 test-rmse:1.620090
## [130]    train-rmse:1.318785 test-rmse:1.618060
## [131]    train-rmse:1.315885 test-rmse:1.618151
## [132]    train-rmse:1.311277 test-rmse:1.613507
## [133]    train-rmse:1.310691 test-rmse:1.612872
## [134]    train-rmse:1.306483 test-rmse:1.608752
## [135]    train-rmse:1.306034 test-rmse:1.608457
## [136]    train-rmse:1.303082 test-rmse:1.607408
```

```
## [137]    train-rmse:1.296411 test-rmse:1.599849
## [138]    train-rmse:1.295552 test-rmse:1.599163
## [139]    train-rmse:1.294744 test-rmse:1.599115
## [140]    train-rmse:1.290441 test-rmse:1.595710
## [141]    train-rmse:1.287200 test-rmse:1.592421
## [142]    train-rmse:1.284782 test-rmse:1.592315
## [143]    train-rmse:1.282586 test-rmse:1.592377
## [144]    train-rmse:1.281815 test-rmse:1.591721
## [145]    train-rmse:1.278517 test-rmse:1.591140
## [146]    train-rmse:1.271560 test-rmse:1.583637
## [147]    train-rmse:1.270942 test-rmse:1.583313
## [148]    train-rmse:1.269645 test-rmse:1.583337
## [149]    train-rmse:1.269129 test-rmse:1.582816
## [150]    train-rmse:1.264631 test-rmse:1.580984
## [151]    train-rmse:1.262346 test-rmse:1.579340
## [152]    train-rmse:1.261868 test-rmse:1.578654
## [153]    train-rmse:1.258986 test-rmse:1.578437
## [154]    train-rmse:1.257060 test-rmse:1.577541
## [155]    train-rmse:1.253879 test-rmse:1.578365
## [156]    train-rmse:1.251544 test-rmse:1.577700
## [157]    train-rmse:1.247925 test-rmse:1.578452
## [158]    train-rmse:1.246271 test-rmse:1.579092
## [159]    train-rmse:1.244289 test-rmse:1.580446
## [160]    train-rmse:1.239992 test-rmse:1.577440
## [161]    train-rmse:1.239750 test-rmse:1.577207
## [162]    train-rmse:1.239119 test-rmse:1.576754
## [163]    train-rmse:1.237228 test-rmse:1.574871
## [164]    train-rmse:1.234416 test-rmse:1.574666
## [165]    train-rmse:1.230523 test-rmse:1.570925
## [166]    train-rmse:1.228721 test-rmse:1.570300
## [167]    train-rmse:1.228139 test-rmse:1.570261
## [168]    train-rmse:1.224696 test-rmse:1.568841
## [169]    train-rmse:1.224266 test-rmse:1.568532
## [170]    train-rmse:1.219612 test-rmse:1.566538
## [171]    train-rmse:1.218963 test-rmse:1.566189
## [172]    train-rmse:1.218448 test-rmse:1.566177
## [173]    train-rmse:1.216544 test-rmse:1.566140
## [174]    train-rmse:1.216161 test-rmse:1.565846
## [175]    train-rmse:1.214414 test-rmse:1.565936
## [176]    train-rmse:1.211280 test-rmse:1.563770
## [177]    train-rmse:1.209292 test-rmse:1.563765
## [178]    train-rmse:1.207408 test-rmse:1.563019
## [179]    train-rmse:1.206819 test-rmse:1.562909
## [180]    train-rmse:1.206577 test-rmse:1.562687
## [181]    train-rmse:1.204693 test-rmse:1.562082
## [182]    train-rmse:1.203101 test-rmse:1.561436
## [183]    train-rmse:1.202802 test-rmse:1.560896
## [184]    train-rmse:1.202375 test-rmse:1.560918
## [185]    train-rmse:1.195316 test-rmse:1.553596
## [186]    train-rmse:1.194559 test-rmse:1.553031
## [187]    train-rmse:1.187209 test-rmse:1.550307
## [188]    train-rmse:1.183251 test-rmse:1.550941
## [189]    train-rmse:1.180023 test-rmse:1.548327
## [190]    train-rmse:1.177454 test-rmse:1.548228
```

```
## [191]    train-rmse:1.174571 test-rmse:1.547705
## [192]    train-rmse:1.167111 test-rmse:1.540799
## [193]    train-rmse:1.165668 test-rmse:1.539590
## [194]    train-rmse:1.164560 test-rmse:1.539329
## [195]    train-rmse:1.159438 test-rmse:1.536934
## [196]    train-rmse:1.156597 test-rmse:1.535671
## [197]    train-rmse:1.155375 test-rmse:1.535013
## [198]    train-rmse:1.154792 test-rmse:1.534522
## [199]    train-rmse:1.153791 test-rmse:1.533636
## [200]    train-rmse:1.152912 test-rmse:1.533153
## [201]    train-rmse:1.152035 test-rmse:1.532870
## [202]    train-rmse:1.149373 test-rmse:1.530117
## [203]    train-rmse:1.144066 test-rmse:1.525522
## [204]    train-rmse:1.139413 test-rmse:1.520761
## [205]    train-rmse:1.138799 test-rmse:1.520453
## [206]    train-rmse:1.138069 test-rmse:1.520208
## [207]    train-rmse:1.136636 test-rmse:1.519211
## [208]    train-rmse:1.134650 test-rmse:1.518774
## [209]    train-rmse:1.131784 test-rmse:1.518163
## [210]    train-rmse:1.130911 test-rmse:1.517391
## [211]    train-rmse:1.130167 test-rmse:1.517339
## [212]    train-rmse:1.129494 test-rmse:1.517639
## [213]    train-rmse:1.129218 test-rmse:1.517622
## [214]    train-rmse:1.128891 test-rmse:1.517514
## [215]    train-rmse:1.124800 test-rmse:1.515925
## [216]    train-rmse:1.119667 test-rmse:1.512646
## [217]    train-rmse:1.114456 test-rmse:1.506183
## [218]    train-rmse:1.110057 test-rmse:1.502018
## [219]    train-rmse:1.107072 test-rmse:1.502519
## [220]    train-rmse:1.104397 test-rmse:1.501225
## [221]    train-rmse:1.103430 test-rmse:1.500996
## [222]    train-rmse:1.099792 test-rmse:1.497052
## [223]    train-rmse:1.098002 test-rmse:1.496502
## [224]    train-rmse:1.096831 test-rmse:1.496355
## [225]    train-rmse:1.094557 test-rmse:1.494286
## [226]    train-rmse:1.091671 test-rmse:1.491588
## [227]    train-rmse:1.089780 test-rmse:1.489421
## [228]    train-rmse:1.085843 test-rmse:1.488951
## [229]    train-rmse:1.081359 test-rmse:1.488340
## [230]    train-rmse:1.078981 test-rmse:1.486136
## [231]    train-rmse:1.077822 test-rmse:1.484651
## [232]    train-rmse:1.075891 test-rmse:1.483419
## [233]    train-rmse:1.074035 test-rmse:1.484097
## [234]    train-rmse:1.073006 test-rmse:1.484448
## [235]    train-rmse:1.071056 test-rmse:1.484111
## [236]    train-rmse:1.069880 test-rmse:1.484191
## [237]    train-rmse:1.069217 test-rmse:1.483998
## [238]    train-rmse:1.068671 test-rmse:1.483648
## [239]    train-rmse:1.066296 test-rmse:1.483166
## [240]    train-rmse:1.064141 test-rmse:1.481132
## [241]    train-rmse:1.062152 test-rmse:1.480315
## [242]    train-rmse:1.060673 test-rmse:1.479573
## [243]    train-rmse:1.060299 test-rmse:1.479299
## [244]    train-rmse:1.059915 test-rmse:1.478360
```

```
## [245]    train-rmse:1.058911 test-rmse:1.478205
## [246]    train-rmse:1.058417 test-rmse:1.478593
## [247]    train-rmse:1.057955 test-rmse:1.478869
## [248]    train-rmse:1.053713 test-rmse:1.473347
## [249]    train-rmse:1.052073 test-rmse:1.473311
## [250]    train-rmse:1.050961 test-rmse:1.473805
## [251]    train-rmse:1.049817 test-rmse:1.472985
## [252]    train-rmse:1.049556 test-rmse:1.472675
## [253]    train-rmse:1.046766 test-rmse:1.470667
## [254]    train-rmse:1.045562 test-rmse:1.469389
## [255]    train-rmse:1.045184 test-rmse:1.469104
## [256]    train-rmse:1.042073 test-rmse:1.468534
## [257]    train-rmse:1.039773 test-rmse:1.468593
## [258]    train-rmse:1.037556 test-rmse:1.468180
## [259]    train-rmse:1.034489 test-rmse:1.465814
## [260]    train-rmse:1.031286 test-rmse:1.462044
## [261]    train-rmse:1.029122 test-rmse:1.461766
## [262]    train-rmse:1.028491 test-rmse:1.460847
## [263]    train-rmse:1.028174 test-rmse:1.460154
## [264]    train-rmse:1.024981 test-rmse:1.457012
## [265]    train-rmse:1.023639 test-rmse:1.455974
## [266]    train-rmse:1.022462 test-rmse:1.455261
## [267]    train-rmse:1.020132 test-rmse:1.451990
## [268]    train-rmse:1.015389 test-rmse:1.449571
## [269]    train-rmse:1.012245 test-rmse:1.448395
## [270]    train-rmse:1.011172 test-rmse:1.447164
## [271]    train-rmse:1.009392 test-rmse:1.445590
## [272]    train-rmse:1.008252 test-rmse:1.445125
## [273]    train-rmse:1.007331 test-rmse:1.444314
## [274]    train-rmse:1.005896 test-rmse:1.444362
## [275]    train-rmse:1.005473 test-rmse:1.444235
## [276]    train-rmse:1.005204 test-rmse:1.444036
## [277]    train-rmse:1.000631 test-rmse:1.440269
## [278]    train-rmse:0.997939 test-rmse:1.439276
## [279]    train-rmse:0.994663 test-rmse:1.437004
## [280]    train-rmse:0.992764 test-rmse:1.434513
## [281]    train-rmse:0.992230 test-rmse:1.434411
## [282]    train-rmse:0.990679 test-rmse:1.433079
## [283]    train-rmse:0.988307 test-rmse:1.431451
## [284]    train-rmse:0.987739 test-rmse:1.431118
## [285]    train-rmse:0.986583 test-rmse:1.430659
## [286]    train-rmse:0.984903 test-rmse:1.429399
## [287]    train-rmse:0.984332 test-rmse:1.429553
## [288]    train-rmse:0.980250 test-rmse:1.424968
## [289]    train-rmse:0.979568 test-rmse:1.424413
## [290]    train-rmse:0.977452 test-rmse:1.424166
## [291]    train-rmse:0.974630 test-rmse:1.420108
## [292]    train-rmse:0.973933 test-rmse:1.418966
## [293]    train-rmse:0.973382 test-rmse:1.418676
## [294]    train-rmse:0.972717 test-rmse:1.418349
## [295]    train-rmse:0.969130 test-rmse:1.415416
## [296]    train-rmse:0.964925 test-rmse:1.413684
## [297]    train-rmse:0.964334 test-rmse:1.414203
## [298]    train-rmse:0.964083 test-rmse:1.414040
```

```
## [299]    train-rmse:0.963594 test-rmse:1.413963
## [300]    train-rmse:0.961702 test-rmse:1.412860
## [301]    train-rmse:0.961344 test-rmse:1.413108
## [302]    train-rmse:0.960516 test-rmse:1.412779
## [303]    train-rmse:0.959259 test-rmse:1.412353
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## [350]    train-rmse:0.895954 test-rmse:1.386726
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## [441]    train-rmse:0.784732 test-rmse:1.350565
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## [514]    train-rmse:0.713546 test-rmse:1.314841
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## [611]    train-rmse:0.642315 test-rmse:1.283526
## [612]    train-rmse:0.641147 test-rmse:1.282869
## [613]    train-rmse:0.640299 test-rmse:1.282349
## [614]    train-rmse:0.639669 test-rmse:1.282343
## [615]    train-rmse:0.639466 test-rmse:1.282237
## [616]    train-rmse:0.638878 test-rmse:1.282155
## [617]    train-rmse:0.638353 test-rmse:1.282149
## [618]    train-rmse:0.637620 test-rmse:1.282138
## [619]    train-rmse:0.636922 test-rmse:1.281293
## [620]    train-rmse:0.636777 test-rmse:1.281234
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## [622]    train-rmse:0.636469 test-rmse:1.280879
```

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## [623]    train-rmse:0.636152 test-rmse:1.280598
## [624]    train-rmse:0.635103 test-rmse:1.279525
## [625]    train-rmse:0.634940 test-rmse:1.279451
## [626]    train-rmse:0.633651 test-rmse:1.277855
## [627]    train-rmse:0.632601 test-rmse:1.277649
## [628]    train-rmse:0.632420 test-rmse:1.277594
## [629]    train-rmse:0.632239 test-rmse:1.277509
## [630]    train-rmse:0.631859 test-rmse:1.277213
## [631]    train-rmse:0.631605 test-rmse:1.276843
## [632]    train-rmse:0.630662 test-rmse:1.274564
## [633]    train-rmse:0.629981 test-rmse:1.274380
## [634]    train-rmse:0.628217 test-rmse:1.273647
## [635]    train-rmse:0.628125 test-rmse:1.273631
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## [637]    train-rmse:0.625611 test-rmse:1.272166
## [638]    train-rmse:0.624406 test-rmse:1.271428
## [639]    train-rmse:0.623578 test-rmse:1.272193
## [640]    train-rmse:0.623302 test-rmse:1.272103
## [641]    train-rmse:0.621711 test-rmse:1.270817
## [642]    train-rmse:0.620845 test-rmse:1.270519
## [643]    train-rmse:0.619711 test-rmse:1.268537
## [644]    train-rmse:0.619219 test-rmse:1.268050
## [645]    train-rmse:0.617963 test-rmse:1.268054
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## [653]    train-rmse:0.613134 test-rmse:1.268172
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## [662]    train-rmse:0.608117 test-rmse:1.266875
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## [664]    train-rmse:0.606842 test-rmse:1.266694
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## [666]    train-rmse:0.605551 test-rmse:1.266793
## [667]    train-rmse:0.604565 test-rmse:1.266091
## [668]    train-rmse:0.603999 test-rmse:1.266395
## [669]    train-rmse:0.603745 test-rmse:1.266294
## [670]    train-rmse:0.603560 test-rmse:1.266196
## [671]    train-rmse:0.603238 test-rmse:1.265789
## [672]    train-rmse:0.603028 test-rmse:1.265345
## [673]    train-rmse:0.602453 test-rmse:1.264170
## [674]    train-rmse:0.601988 test-rmse:1.264652
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## [676]    train-rmse:0.599504 test-rmse:1.263884
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## [677]    train-rmse:0.599002 test-rmse:1.263781
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## [686]    train-rmse:0.592878 test-rmse:1.263819
## [687]    train-rmse:0.592350 test-rmse:1.263566
## [688]    train-rmse:0.591716 test-rmse:1.263074
## [689]    train-rmse:0.591025 test-rmse:1.261615
## [690]    train-rmse:0.590494 test-rmse:1.261699
## [691]    train-rmse:0.589474 test-rmse:1.260816
## [692]    train-rmse:0.588975 test-rmse:1.260891
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## [700]    train-rmse:0.582448 test-rmse:1.255955
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## [706]    train-rmse:0.578849 test-rmse:1.254982
## [707]    train-rmse:0.578006 test-rmse:1.253541
## [708]    train-rmse:0.577260 test-rmse:1.253261
## [709]    train-rmse:0.576388 test-rmse:1.253154
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## [711]    train-rmse:0.575232 test-rmse:1.251679
## [712]    train-rmse:0.575120 test-rmse:1.251688
## [713]    train-rmse:0.575040 test-rmse:1.251657
## [714]    train-rmse:0.573783 test-rmse:1.251356
## [715]    train-rmse:0.572852 test-rmse:1.250782
## [716]    train-rmse:0.572067 test-rmse:1.250659
## [717]    train-rmse:0.571866 test-rmse:1.250683
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## [719]    train-rmse:0.571128 test-rmse:1.249958
## [720]    train-rmse:0.570548 test-rmse:1.249687
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## [722]    train-rmse:0.568601 test-rmse:1.249096
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## [726]    train-rmse:0.567015 test-rmse:1.248683
## [727]    train-rmse:0.566479 test-rmse:1.248436
## [728]    train-rmse:0.566435 test-rmse:1.248450
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## [730]    train-rmse:0.564435 test-rmse:1.246815
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## [731]    train-rmse:0.564312 test-rmse:1.246708
## [732]    train-rmse:0.563556 test-rmse:1.245662
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## [734]    train-rmse:0.561519 test-rmse:1.244982
## [735]    train-rmse:0.560973 test-rmse:1.245770
## [736]    train-rmse:0.560637 test-rmse:1.245233
## [737]    train-rmse:0.560095 test-rmse:1.244859
## [738]    train-rmse:0.559736 test-rmse:1.244900
## [739]    train-rmse:0.559178 test-rmse:1.243935
## [740]    train-rmse:0.558718 test-rmse:1.244350
## [741]    train-rmse:0.558261 test-rmse:1.244430
## [742]    train-rmse:0.557386 test-rmse:1.243418
## [743]    train-rmse:0.556738 test-rmse:1.243643
## [744]    train-rmse:0.556391 test-rmse:1.244268
## [745]    train-rmse:0.556340 test-rmse:1.244248
## [746]    train-rmse:0.555546 test-rmse:1.245397
## [747]    train-rmse:0.554629 test-rmse:1.244483
## [748]    train-rmse:0.553785 test-rmse:1.243530
## [749]    train-rmse:0.553567 test-rmse:1.243451
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## [752]    train-rmse:0.552365 test-rmse:1.244024
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## [754]    train-rmse:0.552090 test-rmse:1.243711
## [755]    train-rmse:0.551211 test-rmse:1.243764
## [756]    train-rmse:0.550953 test-rmse:1.243629
## [757]    train-rmse:0.550831 test-rmse:1.243571
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## [761]    train-rmse:0.547643 test-rmse:1.243785
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## [763]    train-rmse:0.545847 test-rmse:1.244316
## [764]    train-rmse:0.544442 test-rmse:1.244710
## [765]    train-rmse:0.543877 test-rmse:1.244734
## [766]    train-rmse:0.543643 test-rmse:1.244435
## [767]    train-rmse:0.543058 test-rmse:1.244585
## [768]    train-rmse:0.542337 test-rmse:1.244687
## [769]    train-rmse:0.542050 test-rmse:1.244749
## [770]    train-rmse:0.541984 test-rmse:1.244755
## [771]    train-rmse:0.541903 test-rmse:1.244777
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## [773]    train-rmse:0.540944 test-rmse:1.243774
## [774]    train-rmse:0.540540 test-rmse:1.243670
## [775]    train-rmse:0.539617 test-rmse:1.243055
## [776]    train-rmse:0.539126 test-rmse:1.243304
## [777]    train-rmse:0.538669 test-rmse:1.243168
## [778]    train-rmse:0.537803 test-rmse:1.243172
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## [782]    train-rmse:0.535639 test-rmse:1.243615
## [783]    train-rmse:0.535455 test-rmse:1.243500
## [784]    train-rmse:0.534846 test-rmse:1.243056
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## [786]    train-rmse:0.534137 test-rmse:1.242157
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## [788]    train-rmse:0.533377 test-rmse:1.241206
## [789]    train-rmse:0.532250 test-rmse:1.241523
## [790]    train-rmse:0.531421 test-rmse:1.240667
## [791]    train-rmse:0.530112 test-rmse:1.240149
## [792]    train-rmse:0.529789 test-rmse:1.240142
## [793]    train-rmse:0.529099 test-rmse:1.239212
## [794]    train-rmse:0.528550 test-rmse:1.239061
## [795]    train-rmse:0.528311 test-rmse:1.238865
## [796]    train-rmse:0.528098 test-rmse:1.238870
## [797]    train-rmse:0.527583 test-rmse:1.238132
## [798]    train-rmse:0.526917 test-rmse:1.238471
## [799]    train-rmse:0.526677 test-rmse:1.238375
## [800]    train-rmse:0.526381 test-rmse:1.238221
## [801]    train-rmse:0.525489 test-rmse:1.238782
## [802]    train-rmse:0.524802 test-rmse:1.238429
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## [808]    train-rmse:0.522821 test-rmse:1.237229
## [809]    train-rmse:0.522548 test-rmse:1.236940
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## [817]    train-rmse:0.517909 test-rmse:1.233694
## [818]    train-rmse:0.517607 test-rmse:1.233663
## [819]    train-rmse:0.517159 test-rmse:1.233295
## [820]    train-rmse:0.516785 test-rmse:1.233178
## [821]    train-rmse:0.516194 test-rmse:1.233056
## [822]    train-rmse:0.515253 test-rmse:1.232895
## [823]    train-rmse:0.514498 test-rmse:1.232970
## [824]    train-rmse:0.513867 test-rmse:1.232643
## [825]    train-rmse:0.513226 test-rmse:1.232897
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## [828]    train-rmse:0.511995 test-rmse:1.232359
## [829]    train-rmse:0.511041 test-rmse:1.231995
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## [831]    train-rmse:0.510416 test-rmse:1.231682
## [832]    train-rmse:0.509493 test-rmse:1.231740
## [833]    train-rmse:0.508776 test-rmse:1.231696
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## [835]    train-rmse:0.506903 test-rmse:1.231219
## [836]    train-rmse:0.506381 test-rmse:1.230763
## [837]    train-rmse:0.506105 test-rmse:1.230361
## [838]    train-rmse:0.505568 test-rmse:1.230397
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## [839]    train-rmse:0.504787 test-rmse:1.230038
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## [841]    train-rmse:0.503653 test-rmse:1.229956
## [842]    train-rmse:0.502979 test-rmse:1.230063
## [843]    train-rmse:0.502043 test-rmse:1.229882
## [844]    train-rmse:0.500980 test-rmse:1.229457
## [845]    train-rmse:0.500753 test-rmse:1.229003
## [846]    train-rmse:0.499903 test-rmse:1.228375
## [847]    train-rmse:0.499814 test-rmse:1.228311
## [848]    train-rmse:0.499500 test-rmse:1.228510
## [849]    train-rmse:0.499088 test-rmse:1.228359
## [850]    train-rmse:0.498188 test-rmse:1.228655
## [851]    train-rmse:0.497500 test-rmse:1.228678
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## [869]    train-rmse:0.488694 test-rmse:1.225070
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## [871]    train-rmse:0.487957 test-rmse:1.225001
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## [879]    train-rmse:0.483162 test-rmse:1.222745
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## [884]    train-rmse:0.481337 test-rmse:1.221923
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## [892]    train-rmse:0.477313 test-rmse:1.220690
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## [918]    train-rmse:0.466051 test-rmse:1.217076
## [919]    train-rmse:0.465502 test-rmse:1.217054
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## [922]    train-rmse:0.464890 test-rmse:1.216850
## [923]    train-rmse:0.464112 test-rmse:1.216456
## [924]    train-rmse:0.463403 test-rmse:1.216698
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## [927]    train-rmse:0.462440 test-rmse:1.216004
## [928]    train-rmse:0.462332 test-rmse:1.216071
## [929]    train-rmse:0.462199 test-rmse:1.216186
## [930]    train-rmse:0.461900 test-rmse:1.216476
## [931]    train-rmse:0.461550 test-rmse:1.216554
## [932]    train-rmse:0.461383 test-rmse:1.216371
## [933]    train-rmse:0.460842 test-rmse:1.216050
## [934]    train-rmse:0.460195 test-rmse:1.215942
## [935]    train-rmse:0.460083 test-rmse:1.215985
## [936]    train-rmse:0.458962 test-rmse:1.215408
## [937]    train-rmse:0.458536 test-rmse:1.215139
## [938]    train-rmse:0.458422 test-rmse:1.215134
## [939]    train-rmse:0.458289 test-rmse:1.215174
## [940]    train-rmse:0.458255 test-rmse:1.215196
## [941]    train-rmse:0.458032 test-rmse:1.214922
## [942]    train-rmse:0.457668 test-rmse:1.214938
## [943]    train-rmse:0.457515 test-rmse:1.215052
## [944]    train-rmse:0.456634 test-rmse:1.214387
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## [946]    train-rmse:0.455408 test-rmse:1.214058
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## [949]    train-rmse:0.454177 test-rmse:1.213047
## [950]    train-rmse:0.453958 test-rmse:1.213187
## [951]    train-rmse:0.453872 test-rmse:1.213112
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## [956]    train-rmse:0.452754 test-rmse:1.212125
## [957]    train-rmse:0.452475 test-rmse:1.212071
## [958]    train-rmse:0.452135 test-rmse:1.211837
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## [962]    train-rmse:0.450041 test-rmse:1.210628
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## [981]    train-rmse:0.443101 test-rmse:1.209164
## [982]    train-rmse:0.442504 test-rmse:1.209303
## [983]    train-rmse:0.442236 test-rmse:1.208988
## [984]    train-rmse:0.441287 test-rmse:1.209381
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## [987]    train-rmse:0.440468 test-rmse:1.210082
## [988]    train-rmse:0.439974 test-rmse:1.210183
## [989]    train-rmse:0.439545 test-rmse:1.209907
## [990]    train-rmse:0.438581 test-rmse:1.209460
## [991]    train-rmse:0.438147 test-rmse:1.210210
## [992]    train-rmse:0.437530 test-rmse:1.209817
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## [998]    train-rmse:0.434992 test-rmse:1.209108
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## [1003]   train-rmse:0.432896 test-rmse:1.208458
## [1004]   train-rmse:0.432446 test-rmse:1.207591
## [1005]   train-rmse:0.432043 test-rmse:1.207678
## [1006]   train-rmse:0.431633 test-rmse:1.207732
## [1007]   train-rmse:0.431428 test-rmse:1.207705
## [1008]   train-rmse:0.431067 test-rmse:1.207498
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## [1010]   train-rmse:0.430217 test-rmse:1.207400
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## [1012]   train-rmse:0.429041 test-rmse:1.206387
## [1013]   train-rmse:0.428903 test-rmse:1.206391
## [1014]   train-rmse:0.428852 test-rmse:1.206421
## [1015]   train-rmse:0.428612 test-rmse:1.206409
## [1016]   train-rmse:0.428226 test-rmse:1.206191
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## [1054]   train-rmse:0.415655 test-rmse:1.201996
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## [1162]   train-rmse:0.380340 test-rmse:1.192908
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## [1163]   train-rmse:0.379811 test-rmse:1.192949
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## [1217]   train-rmse:0.364118 test-rmse:1.190563
## [1218]   train-rmse:0.363636 test-rmse:1.190594
## [1219]   train-rmse:0.363282 test-rmse:1.190325
## [1220]   train-rmse:0.362904 test-rmse:1.191142
## [1221]   train-rmse:0.362634 test-rmse:1.190607
## [1222]   train-rmse:0.362103 test-rmse:1.190899
## [1223]   train-rmse:0.361724 test-rmse:1.190282
## [1224]   train-rmse:0.361307 test-rmse:1.190109
## [1225]   train-rmse:0.361069 test-rmse:1.190325
## [1226]   train-rmse:0.360651 test-rmse:1.190497
## [1227]   train-rmse:0.360584 test-rmse:1.190447
## [1228]   train-rmse:0.359777 test-rmse:1.189970
## [1229]   train-rmse:0.359312 test-rmse:1.189739
## [1230]   train-rmse:0.359252 test-rmse:1.189802
## [1231]   train-rmse:0.358806 test-rmse:1.190003
## [1232]   train-rmse:0.358748 test-rmse:1.189990
## [1233]   train-rmse:0.358611 test-rmse:1.189992
## [1234]   train-rmse:0.358360 test-rmse:1.189904
## [1235]   train-rmse:0.358294 test-rmse:1.189931
## [1236]   train-rmse:0.358050 test-rmse:1.189805
## [1237]   train-rmse:0.357831 test-rmse:1.189907
## [1238]   train-rmse:0.357450 test-rmse:1.189827
## [1239]   train-rmse:0.357052 test-rmse:1.189389
## [1240]   train-rmse:0.356762 test-rmse:1.189279
## [1241]   train-rmse:0.356695 test-rmse:1.189249
## [1242]   train-rmse:0.356362 test-rmse:1.189189
## [1243]   train-rmse:0.356130 test-rmse:1.189435
## [1244]   train-rmse:0.355876 test-rmse:1.189276
## [1245]   train-rmse:0.355637 test-rmse:1.189299
## [1246]   train-rmse:0.355332 test-rmse:1.189094
## [1247]   train-rmse:0.355027 test-rmse:1.188549
## [1248]   train-rmse:0.354648 test-rmse:1.188629
## [1249]   train-rmse:0.354174 test-rmse:1.188643
## [1250]   train-rmse:0.353857 test-rmse:1.188476
## [1251]   train-rmse:0.353196 test-rmse:1.188814
## [1252]   train-rmse:0.353139 test-rmse:1.188834
## [1253]   train-rmse:0.352906 test-rmse:1.188804
## [1254]   train-rmse:0.352570 test-rmse:1.188802
## [1255]   train-rmse:0.352545 test-rmse:1.188801
## [1256]   train-rmse:0.352304 test-rmse:1.188920
## [1257]   train-rmse:0.351861 test-rmse:1.189000
## [1258]   train-rmse:0.351517 test-rmse:1.189009
## [1259]   train-rmse:0.351026 test-rmse:1.189031
## [1260]   train-rmse:0.350883 test-rmse:1.189073
## [1261]   train-rmse:0.350611 test-rmse:1.189085
## [1262]   train-rmse:0.350456 test-rmse:1.188987
## [1263]   train-rmse:0.350407 test-rmse:1.188982
## [1264]   train-rmse:0.350205 test-rmse:1.188785
## [1265]   train-rmse:0.350128 test-rmse:1.188805
## [1266]   train-rmse:0.349940 test-rmse:1.188463
## [1267]   train-rmse:0.349863 test-rmse:1.188538
## [1268]   train-rmse:0.349512 test-rmse:1.188208
## [1269]   train-rmse:0.349198 test-rmse:1.187994
## [1270]   train-rmse:0.348673 test-rmse:1.188186
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## [1271]   train-rmse:0.348337 test-rmse:1.188032
## [1272]   train-rmse:0.347852 test-rmse:1.187980
## [1273]   train-rmse:0.347615 test-rmse:1.187172
## [1274]   train-rmse:0.347249 test-rmse:1.187528
## [1275]   train-rmse:0.346921 test-rmse:1.187520
## [1276]   train-rmse:0.346691 test-rmse:1.187224
## [1277]   train-rmse:0.346075 test-rmse:1.187095
## [1278]   train-rmse:0.345698 test-rmse:1.187086
## [1279]   train-rmse:0.345395 test-rmse:1.186850
## [1280]   train-rmse:0.344986 test-rmse:1.186479
## [1281]   train-rmse:0.344640 test-rmse:1.186249
## [1282]   train-rmse:0.344474 test-rmse:1.186201
## [1283]   train-rmse:0.344109 test-rmse:1.185948
## [1284]   train-rmse:0.343933 test-rmse:1.185858
## [1285]   train-rmse:0.343661 test-rmse:1.185670
## [1286]   train-rmse:0.343583 test-rmse:1.185712
## [1287]   train-rmse:0.343290 test-rmse:1.185704
## [1288]   train-rmse:0.342870 test-rmse:1.185586
## [1289]   train-rmse:0.342696 test-rmse:1.185603
## [1290]   train-rmse:0.342054 test-rmse:1.184823
## [1291]   train-rmse:0.341949 test-rmse:1.184826
## [1292]   train-rmse:0.341296 test-rmse:1.184174
## [1293]   train-rmse:0.340810 test-rmse:1.184184
## [1294]   train-rmse:0.340392 test-rmse:1.184054
## [1295]   train-rmse:0.340331 test-rmse:1.183952
## [1296]   train-rmse:0.340122 test-rmse:1.184084
## [1297]   train-rmse:0.339562 test-rmse:1.183818
## [1298]   train-rmse:0.339249 test-rmse:1.184078
## [1299]   train-rmse:0.338953 test-rmse:1.184058
## [1300]   train-rmse:0.338492 test-rmse:1.183075
## [1301]   train-rmse:0.338341 test-rmse:1.183248
## [1302]   train-rmse:0.338220 test-rmse:1.183256
## [1303]   train-rmse:0.338197 test-rmse:1.183256
## [1304]   train-rmse:0.338164 test-rmse:1.183210
## [1305]   train-rmse:0.338135 test-rmse:1.183190
## [1306]   train-rmse:0.338041 test-rmse:1.183120
## [1307]   train-rmse:0.337792 test-rmse:1.182884
## [1308]   train-rmse:0.337774 test-rmse:1.182900
## [1309]   train-rmse:0.337743 test-rmse:1.182901
## [1310]   train-rmse:0.337356 test-rmse:1.183027
## [1311]   train-rmse:0.337114 test-rmse:1.183065
## [1312]   train-rmse:0.336892 test-rmse:1.182905
## [1313]   train-rmse:0.336409 test-rmse:1.183102
## [1314]   train-rmse:0.336032 test-rmse:1.183204
## [1315]   train-rmse:0.335835 test-rmse:1.183009
## [1316]   train-rmse:0.335524 test-rmse:1.183279
## [1317]   train-rmse:0.335005 test-rmse:1.183207
## [1318]   train-rmse:0.334912 test-rmse:1.183211
## [1319]   train-rmse:0.334523 test-rmse:1.183115
## [1320]   train-rmse:0.334267 test-rmse:1.183139
## [1321]   train-rmse:0.334064 test-rmse:1.183020
## [1322]   train-rmse:0.333999 test-rmse:1.182979
## [1323]   train-rmse:0.333839 test-rmse:1.182725
## [1324]   train-rmse:0.333674 test-rmse:1.182703
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## [1325]   train-rmse:0.333509 test-rmse:1.182651
## [1326]   train-rmse:0.333207 test-rmse:1.182567
## [1327]   train-rmse:0.332846 test-rmse:1.182544
## [1328]   train-rmse:0.332497 test-rmse:1.182872
## [1329]   train-rmse:0.332043 test-rmse:1.182084
## [1330]   train-rmse:0.331796 test-rmse:1.181815
## [1331]   train-rmse:0.331642 test-rmse:1.181767
## [1332]   train-rmse:0.331419 test-rmse:1.181697
## [1333]   train-rmse:0.331311 test-rmse:1.181672
## [1334]   train-rmse:0.331257 test-rmse:1.181678
## [1335]   train-rmse:0.330781 test-rmse:1.181730
## [1336]   train-rmse:0.330313 test-rmse:1.181828
## [1337]   train-rmse:0.330127 test-rmse:1.181663
## [1338]   train-rmse:0.330007 test-rmse:1.181490
## [1339]   train-rmse:0.329603 test-rmse:1.181207
## [1340]   train-rmse:0.329109 test-rmse:1.180930
## [1341]   train-rmse:0.329017 test-rmse:1.180918
## [1342]   train-rmse:0.328926 test-rmse:1.180951
## [1343]   train-rmse:0.328598 test-rmse:1.180743
## [1344]   train-rmse:0.328463 test-rmse:1.180723
## [1345]   train-rmse:0.328041 test-rmse:1.179954
## [1346]   train-rmse:0.327787 test-rmse:1.180095
## [1347]   train-rmse:0.327469 test-rmse:1.180111
## [1348]   train-rmse:0.327067 test-rmse:1.180148
## [1349]   train-rmse:0.326601 test-rmse:1.180018
## [1350]   train-rmse:0.326420 test-rmse:1.179908
## [1351]   train-rmse:0.325998 test-rmse:1.179514
## [1352]   train-rmse:0.325683 test-rmse:1.178914
## [1353]   train-rmse:0.325585 test-rmse:1.178906
## [1354]   train-rmse:0.325523 test-rmse:1.178998
## [1355]   train-rmse:0.325356 test-rmse:1.179136
## [1356]   train-rmse:0.325305 test-rmse:1.179077
## [1357]   train-rmse:0.325009 test-rmse:1.179071
## [1358]   train-rmse:0.324903 test-rmse:1.179022
## [1359]   train-rmse:0.324532 test-rmse:1.178936
## [1360]   train-rmse:0.324407 test-rmse:1.178909
## [1361]   train-rmse:0.324262 test-rmse:1.178978
## [1362]   train-rmse:0.323985 test-rmse:1.179024
## [1363]   train-rmse:0.323779 test-rmse:1.179007
## [1364]   train-rmse:0.323517 test-rmse:1.178837
## [1365]   train-rmse:0.323185 test-rmse:1.178731
## [1366]   train-rmse:0.323034 test-rmse:1.178802
## [1367]   train-rmse:0.322713 test-rmse:1.178505
## [1368]   train-rmse:0.322649 test-rmse:1.178414
## [1369]   train-rmse:0.322334 test-rmse:1.178303
## [1370]   train-rmse:0.321979 test-rmse:1.178422
## [1371]   train-rmse:0.321519 test-rmse:1.178275
## [1372]   train-rmse:0.321226 test-rmse:1.178407
## [1373]   train-rmse:0.321051 test-rmse:1.178380
## [1374]   train-rmse:0.320757 test-rmse:1.178247
## [1375]   train-rmse:0.320638 test-rmse:1.178395
## [1376]   train-rmse:0.320448 test-rmse:1.178480
## [1377]   train-rmse:0.320112 test-rmse:1.178527
## [1378]   train-rmse:0.319986 test-rmse:1.178366
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## [1379]   train-rmse:0.319430 test-rmse:1.178596
## [1380]   train-rmse:0.319257 test-rmse:1.178607
## [1381]   train-rmse:0.318883 test-rmse:1.178812
## [1382]   train-rmse:0.318697 test-rmse:1.178711
## [1383]   train-rmse:0.318549 test-rmse:1.178680
## [1384]   train-rmse:0.318000 test-rmse:1.178373
## [1385]   train-rmse:0.317771 test-rmse:1.178320
## [1386]   train-rmse:0.317503 test-rmse:1.178375
## [1387]   train-rmse:0.317367 test-rmse:1.178322
## [1388]   train-rmse:0.317217 test-rmse:1.178502
## [1389]   train-rmse:0.316827 test-rmse:1.178413
## [1390]   train-rmse:0.316659 test-rmse:1.178258
## [1391]   train-rmse:0.316550 test-rmse:1.178234
## [1392]   train-rmse:0.316111 test-rmse:1.178276
## [1393]   train-rmse:0.315918 test-rmse:1.178300
## [1394]   train-rmse:0.315756 test-rmse:1.178346
## [1395]   train-rmse:0.315744 test-rmse:1.178342
## [1396]   train-rmse:0.315630 test-rmse:1.178296
## [1397]   train-rmse:0.315312 test-rmse:1.178258
## [1398]   train-rmse:0.314981 test-rmse:1.178546
## [1399]   train-rmse:0.314800 test-rmse:1.178360
## [1400]   train-rmse:0.314564 test-rmse:1.178421
## [1401]   train-rmse:0.314187 test-rmse:1.178028
## [1402]   train-rmse:0.314054 test-rmse:1.178029
## [1403]   train-rmse:0.313738 test-rmse:1.177749
## [1404]   train-rmse:0.313669 test-rmse:1.177831
## [1405]   train-rmse:0.313615 test-rmse:1.177832
## [1406]   train-rmse:0.313338 test-rmse:1.177704
## [1407]   train-rmse:0.313126 test-rmse:1.177650
## [1408]   train-rmse:0.312904 test-rmse:1.177540
## [1409]   train-rmse:0.312713 test-rmse:1.177001
## [1410]   train-rmse:0.312467 test-rmse:1.177242
## [1411]   train-rmse:0.312198 test-rmse:1.177043
## [1412]   train-rmse:0.312124 test-rmse:1.177071
## [1413]   train-rmse:0.312090 test-rmse:1.177058
## [1414]   train-rmse:0.312007 test-rmse:1.176877
## [1415]   train-rmse:0.311922 test-rmse:1.176905
## [1416]   train-rmse:0.311869 test-rmse:1.176891
## [1417]   train-rmse:0.311681 test-rmse:1.176883
## [1418]   train-rmse:0.311669 test-rmse:1.176883
## [1419]   train-rmse:0.311377 test-rmse:1.176648
## [1420]   train-rmse:0.311300 test-rmse:1.176581
## [1421]   train-rmse:0.311267 test-rmse:1.176514
## [1422]   train-rmse:0.310940 test-rmse:1.176469
## [1423]   train-rmse:0.310821 test-rmse:1.176097
## [1424]   train-rmse:0.310736 test-rmse:1.176102
## [1425]   train-rmse:0.310622 test-rmse:1.176218
## [1426]   train-rmse:0.310522 test-rmse:1.176221
## [1427]   train-rmse:0.310305 test-rmse:1.176143
## [1428]   train-rmse:0.310154 test-rmse:1.176126
## [1429]   train-rmse:0.309901 test-rmse:1.175896
## [1430]   train-rmse:0.309572 test-rmse:1.175966
## [1431]   train-rmse:0.309297 test-rmse:1.176108
## [1432]   train-rmse:0.309063 test-rmse:1.176094
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## [1433]   train-rmse:0.308820 test-rmse:1.175716
## [1434]   train-rmse:0.308453 test-rmse:1.175352
## [1435]   train-rmse:0.308241 test-rmse:1.175341
## [1436]   train-rmse:0.307861 test-rmse:1.175236
## [1437]   train-rmse:0.307528 test-rmse:1.174612
## [1438]   train-rmse:0.307457 test-rmse:1.174609
## [1439]   train-rmse:0.307295 test-rmse:1.174352
## [1440]   train-rmse:0.307024 test-rmse:1.174405
## [1441]   train-rmse:0.306755 test-rmse:1.174389
## [1442]   train-rmse:0.306664 test-rmse:1.174358
## [1443]   train-rmse:0.306596 test-rmse:1.174357
## [1444]   train-rmse:0.306489 test-rmse:1.174269
## [1445]   train-rmse:0.306427 test-rmse:1.174322
## [1446]   train-rmse:0.306281 test-rmse:1.174393
## [1447]   train-rmse:0.306095 test-rmse:1.173958
## [1448]   train-rmse:0.305992 test-rmse:1.173948
## [1449]   train-rmse:0.305768 test-rmse:1.173946
## [1450]   train-rmse:0.305430 test-rmse:1.173630
## [1451]   train-rmse:0.305253 test-rmse:1.173339
## [1452]   train-rmse:0.304994 test-rmse:1.173105
## [1453]   train-rmse:0.304845 test-rmse:1.173115
## [1454]   train-rmse:0.304668 test-rmse:1.173017
## [1455]   train-rmse:0.304437 test-rmse:1.172999
## [1456]   train-rmse:0.304286 test-rmse:1.173011
## [1457]   train-rmse:0.303989 test-rmse:1.172929
## [1458]   train-rmse:0.303940 test-rmse:1.172923
## [1459]   train-rmse:0.303833 test-rmse:1.172901
## [1460]   train-rmse:0.303727 test-rmse:1.172914
## [1461]   train-rmse:0.303482 test-rmse:1.172771
## [1462]   train-rmse:0.303226 test-rmse:1.172752
## [1463]   train-rmse:0.302895 test-rmse:1.172406
## [1464]   train-rmse:0.302868 test-rmse:1.172386
## [1465]   train-rmse:0.302566 test-rmse:1.172621
## [1466]   train-rmse:0.301944 test-rmse:1.172414
## [1467]   train-rmse:0.301845 test-rmse:1.172396
## [1468]   train-rmse:0.301708 test-rmse:1.172436
## [1469]   train-rmse:0.301632 test-rmse:1.172452
## [1470]   train-rmse:0.301059 test-rmse:1.171393
## [1471]   train-rmse:0.300629 test-rmse:1.171167
## [1472]   train-rmse:0.300326 test-rmse:1.170807
## [1473]   train-rmse:0.300088 test-rmse:1.170900
## [1474]   train-rmse:0.299810 test-rmse:1.170866
## [1475]   train-rmse:0.299628 test-rmse:1.170907
## [1476]   train-rmse:0.299235 test-rmse:1.170684
## [1477]   train-rmse:0.299111 test-rmse:1.170510
## [1478]   train-rmse:0.298792 test-rmse:1.170494
## [1479]   train-rmse:0.298604 test-rmse:1.170637
## [1480]   train-rmse:0.298342 test-rmse:1.170598
## [1481]   train-rmse:0.298065 test-rmse:1.170629
## [1482]   train-rmse:0.297827 test-rmse:1.170664
## [1483]   train-rmse:0.297278 test-rmse:1.170584
## [1484]   train-rmse:0.297061 test-rmse:1.170612
## [1485]   train-rmse:0.296854 test-rmse:1.170641
## [1486]   train-rmse:0.296557 test-rmse:1.170599
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## [1487]   train-rmse:0.296332 test-rmse:1.170573
## [1488]   train-rmse:0.296090 test-rmse:1.170957
## [1489]   train-rmse:0.295937 test-rmse:1.170696
## [1490]   train-rmse:0.295600 test-rmse:1.170669
## [1491]   train-rmse:0.295333 test-rmse:1.170210
## [1492]   train-rmse:0.295173 test-rmse:1.170317
## [1493]   train-rmse:0.294950 test-rmse:1.170426
## [1494]   train-rmse:0.294889 test-rmse:1.170473
## [1495]   train-rmse:0.294746 test-rmse:1.170616
## [1496]   train-rmse:0.294714 test-rmse:1.170653
## [1497]   train-rmse:0.294704 test-rmse:1.170652
## [1498]   train-rmse:0.294521 test-rmse:1.170693
## [1499]   train-rmse:0.294335 test-rmse:1.170547
## [1500]   train-rmse:0.294120 test-rmse:1.170393
## [1501]   train-rmse:0.293945 test-rmse:1.170281
## [1502]   train-rmse:0.293629 test-rmse:1.170313
## [1503]   train-rmse:0.293294 test-rmse:1.170415
## [1504]   train-rmse:0.292892 test-rmse:1.170738
## [1505]   train-rmse:0.292463 test-rmse:1.170675
## [1506]   train-rmse:0.292326 test-rmse:1.170563
## [1507]   train-rmse:0.292086 test-rmse:1.170552
## [1508]   train-rmse:0.291846 test-rmse:1.170492
## [1509]   train-rmse:0.291623 test-rmse:1.170445
## [1510]   train-rmse:0.291607 test-rmse:1.170431
## [1511]   train-rmse:0.291381 test-rmse:1.170450
## [1512]   train-rmse:0.291120 test-rmse:1.170559
## [1513]   train-rmse:0.290797 test-rmse:1.170259
## [1514]   train-rmse:0.290437 test-rmse:1.170060
## [1515]   train-rmse:0.290285 test-rmse:1.169987
## [1516]   train-rmse:0.290165 test-rmse:1.169977
## [1517]   train-rmse:0.290009 test-rmse:1.169964
## [1518]   train-rmse:0.289858 test-rmse:1.169948
## [1519]   train-rmse:0.289721 test-rmse:1.169929
## [1520]   train-rmse:0.289488 test-rmse:1.169772
## [1521]   train-rmse:0.289104 test-rmse:1.169718
## [1522]   train-rmse:0.289065 test-rmse:1.169756
## [1523]   train-rmse:0.288967 test-rmse:1.169860
## [1524]   train-rmse:0.288723 test-rmse:1.169711
## [1525]   train-rmse:0.288456 test-rmse:1.169517
## [1526]   train-rmse:0.288283 test-rmse:1.169514
## [1527]   train-rmse:0.288058 test-rmse:1.169801
## [1528]   train-rmse:0.287782 test-rmse:1.169692
## [1529]   train-rmse:0.287692 test-rmse:1.169729
## [1530]   train-rmse:0.287508 test-rmse:1.169894
## [1531]   train-rmse:0.287327 test-rmse:1.169881
## [1532]   train-rmse:0.287145 test-rmse:1.170080
## [1533]   train-rmse:0.287059 test-rmse:1.170064
## [1534]   train-rmse:0.287050 test-rmse:1.170091
## [1535]   train-rmse:0.286725 test-rmse:1.169930
## [1536]   train-rmse:0.286494 test-rmse:1.170227
## [1537]   train-rmse:0.286417 test-rmse:1.170164
## [1538]   train-rmse:0.286337 test-rmse:1.170282
## [1539]   train-rmse:0.286191 test-rmse:1.170345
## [1540]   train-rmse:0.286061 test-rmse:1.170318
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## [1541]   train-rmse:0.286018 test-rmse:1.170358
## [1542]   train-rmse:0.286003 test-rmse:1.170378
## [1543]   train-rmse:0.285738 test-rmse:1.170276
## [1544]   train-rmse:0.285605 test-rmse:1.170286
## [1545]   train-rmse:0.285462 test-rmse:1.170433
## [1546]   train-rmse:0.285365 test-rmse:1.170545
## [1547]   train-rmse:0.285184 test-rmse:1.170431
## [1548]   train-rmse:0.284916 test-rmse:1.170402
## [1549]   train-rmse:0.284694 test-rmse:1.170262
## [1550]   train-rmse:0.284552 test-rmse:1.170147
## [1551]   train-rmse:0.284310 test-rmse:1.170112
## [1552]   train-rmse:0.284111 test-rmse:1.170175
## [1553]   train-rmse:0.283927 test-rmse:1.169801
## [1554]   train-rmse:0.283338 test-rmse:1.169764
## [1555]   train-rmse:0.282999 test-rmse:1.169998
## [1556]   train-rmse:0.282767 test-rmse:1.169809
## [1557]   train-rmse:0.282538 test-rmse:1.169770
## [1558]   train-rmse:0.282242 test-rmse:1.169523
## [1559]   train-rmse:0.282109 test-rmse:1.169531
## [1560]   train-rmse:0.282066 test-rmse:1.169494
## [1561]   train-rmse:0.281963 test-rmse:1.169432
## [1562]   train-rmse:0.281780 test-rmse:1.169245
## [1563]   train-rmse:0.281719 test-rmse:1.169257
## [1564]   train-rmse:0.281656 test-rmse:1.169261
## [1565]   train-rmse:0.281634 test-rmse:1.169269
## [1566]   train-rmse:0.281412 test-rmse:1.169210
## [1567]   train-rmse:0.281013 test-rmse:1.169045
## [1568]   train-rmse:0.280855 test-rmse:1.169030
## [1569]   train-rmse:0.280611 test-rmse:1.168779
## [1570]   train-rmse:0.280194 test-rmse:1.168929
## [1571]   train-rmse:0.279736 test-rmse:1.168963
## [1572]   train-rmse:0.279680 test-rmse:1.169026
## [1573]   train-rmse:0.279407 test-rmse:1.169145
## [1574]   train-rmse:0.279194 test-rmse:1.168956
## [1575]   train-rmse:0.278911 test-rmse:1.168988
## [1576]   train-rmse:0.278876 test-rmse:1.168948
## [1577]   train-rmse:0.278773 test-rmse:1.168880
## [1578]   train-rmse:0.278727 test-rmse:1.168860
## [1579]   train-rmse:0.278573 test-rmse:1.169008
## [1580]   train-rmse:0.278383 test-rmse:1.168705
## [1581]   train-rmse:0.277947 test-rmse:1.168863
## [1582]   train-rmse:0.277646 test-rmse:1.168997
## [1583]   train-rmse:0.277171 test-rmse:1.169549
## [1584]   train-rmse:0.276806 test-rmse:1.169686
## [1585]   train-rmse:0.276715 test-rmse:1.169647
## [1586]   train-rmse:0.276580 test-rmse:1.169628
## [1587]   train-rmse:0.276532 test-rmse:1.169662
## [1588]   train-rmse:0.276192 test-rmse:1.169517
## [1589]   train-rmse:0.275906 test-rmse:1.169568
## [1590]   train-rmse:0.275638 test-rmse:1.169584
## [1591]   train-rmse:0.275446 test-rmse:1.169607
## [1592]   train-rmse:0.275379 test-rmse:1.169590
## [1593]   train-rmse:0.275220 test-rmse:1.169556
## [1594]   train-rmse:0.274912 test-rmse:1.169631
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## [1595]   train-rmse:0.274638 test-rmse:1.169431
## [1596]   train-rmse:0.274381 test-rmse:1.169624
## [1597]   train-rmse:0.274205 test-rmse:1.169676
## [1598]   train-rmse:0.273989 test-rmse:1.169529
## [1599]   train-rmse:0.273663 test-rmse:1.169517
## [1600]   train-rmse:0.273429 test-rmse:1.169341
## [1601]   train-rmse:0.273241 test-rmse:1.169445
## [1602]   train-rmse:0.273101 test-rmse:1.169382
## [1603]   train-rmse:0.272922 test-rmse:1.169422
## [1604]   train-rmse:0.272642 test-rmse:1.169336
## [1605]   train-rmse:0.272598 test-rmse:1.169318
## [1606]   train-rmse:0.272378 test-rmse:1.169258
## [1607]   train-rmse:0.272180 test-rmse:1.169277
## [1608]   train-rmse:0.272146 test-rmse:1.169261
## [1609]   train-rmse:0.271911 test-rmse:1.169215
## [1610]   train-rmse:0.271804 test-rmse:1.169172
## [1611]   train-rmse:0.271671 test-rmse:1.169270
## [1612]   train-rmse:0.271434 test-rmse:1.169097
## [1613]   train-rmse:0.271350 test-rmse:1.169067
## [1614]   train-rmse:0.271188 test-rmse:1.169071
## [1615]   train-rmse:0.271013 test-rmse:1.168876
## [1616]   train-rmse:0.270988 test-rmse:1.168869
## [1617]   train-rmse:0.270725 test-rmse:1.168707
## [1618]   train-rmse:0.270664 test-rmse:1.168711
## [1619]   train-rmse:0.270643 test-rmse:1.168707
## [1620]   train-rmse:0.270242 test-rmse:1.168946
## [1621]   train-rmse:0.269973 test-rmse:1.168997
## [1622]   train-rmse:0.269735 test-rmse:1.168887
## [1623]   train-rmse:0.269564 test-rmse:1.168829
## [1624]   train-rmse:0.269407 test-rmse:1.168913
## [1625]   train-rmse:0.269176 test-rmse:1.168856
## [1626]   train-rmse:0.269084 test-rmse:1.168843
## [1627]   train-rmse:0.268732 test-rmse:1.168941
## [1628]   train-rmse:0.268568 test-rmse:1.168919
## [1629]   train-rmse:0.268385 test-rmse:1.168801
## [1630]   train-rmse:0.268176 test-rmse:1.169091
## [1631]   train-rmse:0.268055 test-rmse:1.169126
## [1632]   train-rmse:0.267893 test-rmse:1.169233
## [1633]   train-rmse:0.267818 test-rmse:1.169107
## [1634]   train-rmse:0.267747 test-rmse:1.169242
## [1635]   train-rmse:0.267706 test-rmse:1.169239
## [1636]   train-rmse:0.267551 test-rmse:1.169277
## [1637]   train-rmse:0.267492 test-rmse:1.169292
## [1638]   train-rmse:0.267462 test-rmse:1.169321
## [1639]   train-rmse:0.267398 test-rmse:1.169231
## [1640]   train-rmse:0.267128 test-rmse:1.169250
## [1641]   train-rmse:0.267035 test-rmse:1.169250
## [1642]   train-rmse:0.266841 test-rmse:1.168976
## [1643]   train-rmse:0.266695 test-rmse:1.168889
## [1644]   train-rmse:0.266555 test-rmse:1.168862
## [1645]   train-rmse:0.266433 test-rmse:1.169112
## [1646]   train-rmse:0.266275 test-rmse:1.169229
## [1647]   train-rmse:0.266194 test-rmse:1.169245
## [1648]   train-rmse:0.266186 test-rmse:1.169254
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## [1649]   train-rmse:0.266098 test-rmse:1.169213
## [1650]   train-rmse:0.265910 test-rmse:1.169188
## [1651]   train-rmse:0.265680 test-rmse:1.169184
## [1652]   train-rmse:0.265473 test-rmse:1.169144
## [1653]   train-rmse:0.265363 test-rmse:1.169054
## [1654]   train-rmse:0.265226 test-rmse:1.169019
## [1655]   train-rmse:0.265050 test-rmse:1.168989
## [1656]   train-rmse:0.264838 test-rmse:1.168915
## [1657]   train-rmse:0.264594 test-rmse:1.169019
## [1658]   train-rmse:0.264420 test-rmse:1.168822
## [1659]   train-rmse:0.264349 test-rmse:1.168811
## [1660]   train-rmse:0.264325 test-rmse:1.168813
## [1661]   train-rmse:0.264296 test-rmse:1.168798
## [1662]   train-rmse:0.264291 test-rmse:1.168804
## [1663]   train-rmse:0.264051 test-rmse:1.168792
## [1664]   train-rmse:0.263895 test-rmse:1.168674
## [1665]   train-rmse:0.263651 test-rmse:1.168669
## [1666]   train-rmse:0.263531 test-rmse:1.168557
## [1667]   train-rmse:0.263276 test-rmse:1.168617
## [1668]   train-rmse:0.263005 test-rmse:1.168652
## [1669]   train-rmse:0.262787 test-rmse:1.168818
## [1670]   train-rmse:0.262671 test-rmse:1.168801
## [1671]   train-rmse:0.262627 test-rmse:1.168842
## [1672]   train-rmse:0.262228 test-rmse:1.168970
## [1673]   train-rmse:0.262094 test-rmse:1.168952
## [1674]   train-rmse:0.262073 test-rmse:1.168939
## [1675]   train-rmse:0.262028 test-rmse:1.168922
## [1676]   train-rmse:0.261709 test-rmse:1.168952
## [1677]   train-rmse:0.261480 test-rmse:1.168918
## [1678]   train-rmse:0.261299 test-rmse:1.168909
## [1679]   train-rmse:0.261203 test-rmse:1.168783
## [1680]   train-rmse:0.261106 test-rmse:1.168825
## [1681]   train-rmse:0.260848 test-rmse:1.168772
## [1682]   train-rmse:0.260724 test-rmse:1.168884
## [1683]   train-rmse:0.260634 test-rmse:1.168842
## [1684]   train-rmse:0.260502 test-rmse:1.168755
## [1685]   train-rmse:0.260394 test-rmse:1.168715
## [1686]   train-rmse:0.260293 test-rmse:1.168745
## [1687]   train-rmse:0.260134 test-rmse:1.168734
## [1688]   train-rmse:0.259911 test-rmse:1.168712
## [1689]   train-rmse:0.259863 test-rmse:1.168725
## [1690]   train-rmse:0.259688 test-rmse:1.168566
## [1691]   train-rmse:0.259585 test-rmse:1.168581
## [1692]   train-rmse:0.259533 test-rmse:1.168587
## [1693]   train-rmse:0.259244 test-rmse:1.168576
## [1694]   train-rmse:0.258881 test-rmse:1.168509
## [1695]   train-rmse:0.258860 test-rmse:1.168506
## [1696]   train-rmse:0.258708 test-rmse:1.168541
## [1697]   train-rmse:0.258570 test-rmse:1.168541
## [1698]   train-rmse:0.258384 test-rmse:1.168565
## [1699]   train-rmse:0.258061 test-rmse:1.168570
## [1700]   train-rmse:0.258043 test-rmse:1.168570
## [1701]   train-rmse:0.258016 test-rmse:1.168614
## [1702]   train-rmse:0.257742 test-rmse:1.168610
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## [1703]   train-rmse:0.257455 test-rmse:1.168562
## [1704]   train-rmse:0.257254 test-rmse:1.168549
## [1705]   train-rmse:0.257129 test-rmse:1.168631
## [1706]   train-rmse:0.256833 test-rmse:1.168618
## [1707]   train-rmse:0.256690 test-rmse:1.168555
## [1708]   train-rmse:0.256473 test-rmse:1.168543
## [1709]   train-rmse:0.256193 test-rmse:1.168426
## [1710]   train-rmse:0.255899 test-rmse:1.168188
## [1711]   train-rmse:0.255705 test-rmse:1.168259
## [1712]   train-rmse:0.255682 test-rmse:1.168280
## [1713]   train-rmse:0.255558 test-rmse:1.168215
## [1714]   train-rmse:0.255500 test-rmse:1.168268
## [1715]   train-rmse:0.255444 test-rmse:1.168330
## [1716]   train-rmse:0.255374 test-rmse:1.168329
## [1717]   train-rmse:0.255299 test-rmse:1.168356
## [1718]   train-rmse:0.255199 test-rmse:1.168370
## [1719]   train-rmse:0.254948 test-rmse:1.168268
## [1720]   train-rmse:0.254880 test-rmse:1.168254
## [1721]   train-rmse:0.254776 test-rmse:1.168114
## [1722]   train-rmse:0.254714 test-rmse:1.168052
## [1723]   train-rmse:0.254506 test-rmse:1.167988
## [1724]   train-rmse:0.254318 test-rmse:1.167876
## [1725]   train-rmse:0.254187 test-rmse:1.167831
## [1726]   train-rmse:0.254065 test-rmse:1.167769
## [1727]   train-rmse:0.253848 test-rmse:1.167721
## [1728]   train-rmse:0.253649 test-rmse:1.167882
## [1729]   train-rmse:0.253533 test-rmse:1.167913
## [1730]   train-rmse:0.253351 test-rmse:1.167990
## [1731]   train-rmse:0.253122 test-rmse:1.167996
## [1732]   train-rmse:0.253049 test-rmse:1.167952
## [1733]   train-rmse:0.252979 test-rmse:1.167912
## [1734]   train-rmse:0.252682 test-rmse:1.167954
## [1735]   train-rmse:0.252556 test-rmse:1.167978
## [1736]   train-rmse:0.252396 test-rmse:1.167980
## [1737]   train-rmse:0.252343 test-rmse:1.167791
## [1738]   train-rmse:0.252148 test-rmse:1.167750
## [1739]   train-rmse:0.252070 test-rmse:1.167868
## [1740]   train-rmse:0.252036 test-rmse:1.167917
## [1741]   train-rmse:0.251846 test-rmse:1.167838
## [1742]   train-rmse:0.251672 test-rmse:1.167646
## [1743]   train-rmse:0.251260 test-rmse:1.167579
## [1744]   train-rmse:0.251137 test-rmse:1.167484
## [1745]   train-rmse:0.251029 test-rmse:1.167489
## [1746]   train-rmse:0.250786 test-rmse:1.167330
## [1747]   train-rmse:0.250520 test-rmse:1.167335
## [1748]   train-rmse:0.250493 test-rmse:1.167272
## [1749]   train-rmse:0.250338 test-rmse:1.167166
## [1750]   train-rmse:0.250104 test-rmse:1.167155
## [1751]   train-rmse:0.249966 test-rmse:1.166942
## [1752]   train-rmse:0.249870 test-rmse:1.166966
## [1753]   train-rmse:0.249631 test-rmse:1.167052
## [1754]   train-rmse:0.249444 test-rmse:1.167166
## [1755]   train-rmse:0.249384 test-rmse:1.167156
## [1756]   train-rmse:0.249348 test-rmse:1.167149
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## [1757]   train-rmse:0.249242 test-rmse:1.167077
## [1758]   train-rmse:0.249165 test-rmse:1.167086
## [1759]   train-rmse:0.249117 test-rmse:1.167020
## [1760]   train-rmse:0.248872 test-rmse:1.167101
## [1761]   train-rmse:0.248716 test-rmse:1.167059
## [1762]   train-rmse:0.248653 test-rmse:1.167058
## [1763]   train-rmse:0.248447 test-rmse:1.166808
## [1764]   train-rmse:0.248393 test-rmse:1.166762
## [1765]   train-rmse:0.248179 test-rmse:1.166794
## [1766]   train-rmse:0.248168 test-rmse:1.166791
## [1767]   train-rmse:0.247816 test-rmse:1.166851
## [1768]   train-rmse:0.247635 test-rmse:1.166820
## [1769]   train-rmse:0.247389 test-rmse:1.166207
## [1770]   train-rmse:0.247298 test-rmse:1.166304
## [1771]   train-rmse:0.247140 test-rmse:1.166058
## [1772]   train-rmse:0.246992 test-rmse:1.166093
## [1773]   train-rmse:0.246849 test-rmse:1.166017
## [1774]   train-rmse:0.246780 test-rmse:1.166013
## [1775]   train-rmse:0.246736 test-rmse:1.166008
## [1776]   train-rmse:0.246605 test-rmse:1.165937
## [1777]   train-rmse:0.246502 test-rmse:1.165985
## [1778]   train-rmse:0.246423 test-rmse:1.166100
## [1779]   train-rmse:0.246359 test-rmse:1.166199
## [1780]   train-rmse:0.246329 test-rmse:1.166179
## [1781]   train-rmse:0.246204 test-rmse:1.166155
## [1782]   train-rmse:0.246046 test-rmse:1.166208
## [1783]   train-rmse:0.245963 test-rmse:1.166108
## [1784]   train-rmse:0.245681 test-rmse:1.166143
## [1785]   train-rmse:0.245577 test-rmse:1.166207
## [1786]   train-rmse:0.245479 test-rmse:1.166188
## [1787]   train-rmse:0.245333 test-rmse:1.166307
## [1788]   train-rmse:0.245268 test-rmse:1.166411
## [1789]   train-rmse:0.245041 test-rmse:1.166357
## [1790]   train-rmse:0.244854 test-rmse:1.166398
## [1791]   train-rmse:0.244711 test-rmse:1.166367
## [1792]   train-rmse:0.244552 test-rmse:1.166298
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## [1794]   train-rmse:0.244286 test-rmse:1.166480
## [1795]   train-rmse:0.244250 test-rmse:1.166481
## [1796]   train-rmse:0.244159 test-rmse:1.166474
## [1797]   train-rmse:0.244137 test-rmse:1.166492
## [1798]   train-rmse:0.243935 test-rmse:1.166386
## [1799]   train-rmse:0.243876 test-rmse:1.166418
## [1800]   train-rmse:0.243832 test-rmse:1.166425
## [1801]   train-rmse:0.243622 test-rmse:1.166410
## [1802]   train-rmse:0.243588 test-rmse:1.166344
## [1803]   train-rmse:0.243370 test-rmse:1.166438
## [1804]   train-rmse:0.243347 test-rmse:1.166404
## [1805]   train-rmse:0.243125 test-rmse:1.166567
## [1806]   train-rmse:0.242897 test-rmse:1.166364
## [1807]   train-rmse:0.242671 test-rmse:1.166370
## [1808]   train-rmse:0.242474 test-rmse:1.165984
## [1809]   train-rmse:0.242306 test-rmse:1.166013
## [1810]   train-rmse:0.242119 test-rmse:1.165730
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## [1811]   train-rmse:0.242079 test-rmse:1.165719
## [1812]   train-rmse:0.241928 test-rmse:1.165622
## [1813]   train-rmse:0.241748 test-rmse:1.165565
## [1814]   train-rmse:0.241567 test-rmse:1.165592
## [1815]   train-rmse:0.241417 test-rmse:1.165596
## [1816]   train-rmse:0.241332 test-rmse:1.165613
## [1817]   train-rmse:0.241316 test-rmse:1.165612
## [1818]   train-rmse:0.241283 test-rmse:1.165629
## [1819]   train-rmse:0.241262 test-rmse:1.165625
## [1820]   train-rmse:0.241113 test-rmse:1.165625
## [1821]   train-rmse:0.240931 test-rmse:1.165645
## [1822]   train-rmse:0.240671 test-rmse:1.165663
## [1823]   train-rmse:0.240481 test-rmse:1.165480
## [1824]   train-rmse:0.240204 test-rmse:1.165485
## [1825]   train-rmse:0.240084 test-rmse:1.165502
## [1826]   train-rmse:0.239836 test-rmse:1.165345
## [1827]   train-rmse:0.239634 test-rmse:1.165460
## [1828]   train-rmse:0.239489 test-rmse:1.165546
## [1829]   train-rmse:0.239475 test-rmse:1.165551
## [1830]   train-rmse:0.239457 test-rmse:1.165561
## [1831]   train-rmse:0.239289 test-rmse:1.165605
## [1832]   train-rmse:0.239197 test-rmse:1.165422
## [1833]   train-rmse:0.238893 test-rmse:1.165228
## [1834]   train-rmse:0.238847 test-rmse:1.165212
## [1835]   train-rmse:0.238735 test-rmse:1.164911
## [1836]   train-rmse:0.238699 test-rmse:1.164845
## [1837]   train-rmse:0.238525 test-rmse:1.164738
## [1838]   train-rmse:0.238382 test-rmse:1.164673
## [1839]   train-rmse:0.238302 test-rmse:1.164662
## [1840]   train-rmse:0.238082 test-rmse:1.164209
## [1841]   train-rmse:0.238000 test-rmse:1.164280
## [1842]   train-rmse:0.237838 test-rmse:1.164199
## [1843]   train-rmse:0.237814 test-rmse:1.164156
## [1844]   train-rmse:0.237606 test-rmse:1.164236
## [1845]   train-rmse:0.237485 test-rmse:1.164311
## [1846]   train-rmse:0.237128 test-rmse:1.163766
## [1847]   train-rmse:0.237030 test-rmse:1.163522
## [1848]   train-rmse:0.237010 test-rmse:1.163494
## [1849]   train-rmse:0.236854 test-rmse:1.163568
## [1850]   train-rmse:0.236612 test-rmse:1.163516
## [1851]   train-rmse:0.236396 test-rmse:1.163375
## [1852]   train-rmse:0.236306 test-rmse:1.163316
## [1853]   train-rmse:0.236169 test-rmse:1.163343
## [1854]   train-rmse:0.235953 test-rmse:1.163439
## [1855]   train-rmse:0.235779 test-rmse:1.163432
## [1856]   train-rmse:0.235677 test-rmse:1.163580
## [1857]   train-rmse:0.235493 test-rmse:1.163515
## [1858]   train-rmse:0.235285 test-rmse:1.163442
## [1859]   train-rmse:0.235055 test-rmse:1.163755
## [1860]   train-rmse:0.234942 test-rmse:1.163844
## [1861]   train-rmse:0.234764 test-rmse:1.163839
## [1862]   train-rmse:0.234588 test-rmse:1.163911
## [1863]   train-rmse:0.234380 test-rmse:1.163713
## [1864]   train-rmse:0.234189 test-rmse:1.163678
```

```
## [1865]   train-rmse:0.234162 test-rmse:1.163669
## [1866]   train-rmse:0.234114 test-rmse:1.163701
## [1867]   train-rmse:0.233993 test-rmse:1.163597
## [1868]   train-rmse:0.233868 test-rmse:1.163609
## [1869]   train-rmse:0.233660 test-rmse:1.163713
## [1870]   train-rmse:0.233437 test-rmse:1.163613
## [1871]   train-rmse:0.233406 test-rmse:1.163592
## [1872]   train-rmse:0.233256 test-rmse:1.163415
## [1873]   train-rmse:0.233203 test-rmse:1.163418
## [1874]   train-rmse:0.233153 test-rmse:1.163400
## [1875]   train-rmse:0.233148 test-rmse:1.163404
## [1876]   train-rmse:0.232979 test-rmse:1.163363
## [1877]   train-rmse:0.232953 test-rmse:1.163371
## [1878]   train-rmse:0.232854 test-rmse:1.163387
## [1879]   train-rmse:0.232828 test-rmse:1.163373
## [1880]   train-rmse:0.232737 test-rmse:1.163354
## [1881]   train-rmse:0.232692 test-rmse:1.163317
## [1882]   train-rmse:0.232624 test-rmse:1.163371
## [1883]   train-rmse:0.232483 test-rmse:1.163371
## [1884]   train-rmse:0.232311 test-rmse:1.163337
## [1885]   train-rmse:0.232210 test-rmse:1.163421
## [1886]   train-rmse:0.232153 test-rmse:1.163411
## [1887]   train-rmse:0.232136 test-rmse:1.163409
## [1888]   train-rmse:0.231825 test-rmse:1.163018
## [1889]   train-rmse:0.231642 test-rmse:1.162923
## [1890]   train-rmse:0.231577 test-rmse:1.162901
## [1891]   train-rmse:0.231355 test-rmse:1.162625
## [1892]   train-rmse:0.231092 test-rmse:1.162368
## [1893]   train-rmse:0.230992 test-rmse:1.162254
## [1894]   train-rmse:0.230852 test-rmse:1.162460
## [1895]   train-rmse:0.230724 test-rmse:1.162403
## [1896]   train-rmse:0.230664 test-rmse:1.162403
## [1897]   train-rmse:0.230623 test-rmse:1.162420
## [1898]   train-rmse:0.230473 test-rmse:1.162191
## [1899]   train-rmse:0.230267 test-rmse:1.162145
## [1900]   train-rmse:0.230185 test-rmse:1.162135
## [1901]   train-rmse:0.230057 test-rmse:1.162225
## [1902]   train-rmse:0.230027 test-rmse:1.162234
## [1903]   train-rmse:0.229957 test-rmse:1.162297
## [1904]   train-rmse:0.229722 test-rmse:1.162209
## [1905]   train-rmse:0.229422 test-rmse:1.161559
## [1906]   train-rmse:0.229243 test-rmse:1.161468
## [1907]   train-rmse:0.229053 test-rmse:1.161470
## [1908]   train-rmse:0.228918 test-rmse:1.161480
## [1909]   train-rmse:0.228783 test-rmse:1.161513
## [1910]   train-rmse:0.228513 test-rmse:1.161409
## [1911]   train-rmse:0.228357 test-rmse:1.161294
## [1912]   train-rmse:0.228301 test-rmse:1.161387
## [1913]   train-rmse:0.228183 test-rmse:1.161412
## [1914]   train-rmse:0.228029 test-rmse:1.161398
## [1915]   train-rmse:0.227897 test-rmse:1.161412
## [1916]   train-rmse:0.227850 test-rmse:1.161477
## [1917]   train-rmse:0.227715 test-rmse:1.161469
## [1918]   train-rmse:0.227482 test-rmse:1.161319
```

```
## [1919]   train-rmse:0.227082 test-rmse:1.161226
## [1920]   train-rmse:0.226973 test-rmse:1.161227
## [1921]   train-rmse:0.226875 test-rmse:1.161157
## [1922]   train-rmse:0.226788 test-rmse:1.161187
## [1923]   train-rmse:0.226729 test-rmse:1.161215
## [1924]   train-rmse:0.226579 test-rmse:1.161279
## [1925]   train-rmse:0.226385 test-rmse:1.161187
## [1926]   train-rmse:0.226152 test-rmse:1.161148
## [1927]   train-rmse:0.226043 test-rmse:1.161182
## [1928]   train-rmse:0.225864 test-rmse:1.161167
## [1929]   train-rmse:0.225694 test-rmse:1.161101
## [1930]   train-rmse:0.225667 test-rmse:1.161094
## [1931]   train-rmse:0.225512 test-rmse:1.161059
## [1932]   train-rmse:0.225290 test-rmse:1.160990
## [1933]   train-rmse:0.225102 test-rmse:1.160894
## [1934]   train-rmse:0.225075 test-rmse:1.160861
## [1935]   train-rmse:0.224912 test-rmse:1.161041
## [1936]   train-rmse:0.224631 test-rmse:1.161144
## [1937]   train-rmse:0.224450 test-rmse:1.160880
## [1938]   train-rmse:0.224324 test-rmse:1.160804
## [1939]   train-rmse:0.224207 test-rmse:1.160724
## [1940]   train-rmse:0.224156 test-rmse:1.160670
## [1941]   train-rmse:0.224012 test-rmse:1.160691
## [1942]   train-rmse:0.223971 test-rmse:1.160592
## [1943]   train-rmse:0.223842 test-rmse:1.160492
## [1944]   train-rmse:0.223691 test-rmse:1.160480
## [1945]   train-rmse:0.223483 test-rmse:1.160513
## [1946]   train-rmse:0.223346 test-rmse:1.160427
## [1947]   train-rmse:0.223234 test-rmse:1.160336
## [1948]   train-rmse:0.223088 test-rmse:1.160411
## [1949]   train-rmse:0.222927 test-rmse:1.160522
## [1950]   train-rmse:0.222890 test-rmse:1.160474
## [1951]   train-rmse:0.222735 test-rmse:1.160323
## [1952]   train-rmse:0.222604 test-rmse:1.160358
## [1953]   train-rmse:0.222429 test-rmse:1.160331
## [1954]   train-rmse:0.222173 test-rmse:1.160410
## [1955]   train-rmse:0.222016 test-rmse:1.160454
## [1956]   train-rmse:0.221924 test-rmse:1.160512
## [1957]   train-rmse:0.221729 test-rmse:1.160356
## [1958]   train-rmse:0.221669 test-rmse:1.160368
## [1959]   train-rmse:0.221471 test-rmse:1.160411
## [1960]   train-rmse:0.221388 test-rmse:1.160239
## [1961]   train-rmse:0.221294 test-rmse:1.160234
## [1962]   train-rmse:0.221202 test-rmse:1.160302
## [1963]   train-rmse:0.220967 test-rmse:1.160307
## [1964]   train-rmse:0.220829 test-rmse:1.160218
## [1965]   train-rmse:0.220769 test-rmse:1.160256
## [1966]   train-rmse:0.220740 test-rmse:1.160287
## [1967]   train-rmse:0.220488 test-rmse:1.160511
## [1968]   train-rmse:0.220343 test-rmse:1.160482
## [1969]   train-rmse:0.220203 test-rmse:1.160255
## [1970]   train-rmse:0.220194 test-rmse:1.160255
## [1971]   train-rmse:0.220160 test-rmse:1.160238
## [1972]   train-rmse:0.220094 test-rmse:1.160326
```

```
## [1973]   train-rmse:0.219947 test-rmse:1.160324
## [1974]   train-rmse:0.219846 test-rmse:1.160296
## [1975]   train-rmse:0.219666 test-rmse:1.160269
## [1976]   train-rmse:0.219476 test-rmse:1.160052
## [1977]   train-rmse:0.219379 test-rmse:1.159982
## [1978]   train-rmse:0.219336 test-rmse:1.159970
## [1979]   train-rmse:0.219264 test-rmse:1.159940
## [1980]   train-rmse:0.219071 test-rmse:1.160004
## [1981]   train-rmse:0.218982 test-rmse:1.159935
## [1982]   train-rmse:0.218948 test-rmse:1.159938
## [1983]   train-rmse:0.218858 test-rmse:1.159929
## [1984]   train-rmse:0.218681 test-rmse:1.159976
## [1985]   train-rmse:0.218666 test-rmse:1.159981
## [1986]   train-rmse:0.218516 test-rmse:1.159943
## [1987]   train-rmse:0.218341 test-rmse:1.159901
## [1988]   train-rmse:0.218329 test-rmse:1.159914
## [1989]   train-rmse:0.218218 test-rmse:1.159800
## [1990]   train-rmse:0.218165 test-rmse:1.159816
## [1991]   train-rmse:0.218119 test-rmse:1.159834
## [1992]   train-rmse:0.217939 test-rmse:1.159867
## [1993]   train-rmse:0.217792 test-rmse:1.159669
## [1994]   train-rmse:0.217770 test-rmse:1.159661
## [1995]   train-rmse:0.217615 test-rmse:1.159454
## [1996]   train-rmse:0.217596 test-rmse:1.159429
## [1997]   train-rmse:0.217493 test-rmse:1.159527
## [1998]   train-rmse:0.217363 test-rmse:1.159513
## [1999]   train-rmse:0.217327 test-rmse:1.159474
## [2000]   train-rmse:0.217187 test-rmse:1.159458
```

```
prediction1<-predict(final_boost_1, xgb_test_air)
#print(prediction)
prediction1<-round(prediction1,0)
#prediction1<-lapply(prediction1, function(x) ifelse(x <0, 0, x))
#prediction1
for (i in 1:length(prediction1)){
  #print(i)
  if (prediction1[i]<0){
    prediction1[i]<-0
    #print(prediction1[i])
  }
  if (prediction1[i]>11){
    prediction1[i]<-11
  }
}
#test_air$month[]
#test_air$mont
#test_air_y
#unique(prediction1)
cm1<-(confusionMatrix(data = factor(prediction1), reference = factor(test_air_y)))
cm1
```

```
## Confusion Matrix and Statistics
##
##           Reference
```

```
## Prediction   0   1   2   3   4   5   6   7   8   9  10  11
##         0   56   9  14   1   0   0   0   0   0   0   0   0
##         1   55  32  34   6   0   0   0   0   0   0   0   0
##         2   21  43  49  32   2   0   0   0   0   0   0   2
##         3   10  20  30  80   1   0   0   0   0   0   0   0
##         4    7  14  12  34  16   9   0   0   0   1   0   2
##         5    2   7   8   9   7 259   2   0   0   2   0   6
##         6    0   2   3   1   2  11 565   2   1  10   4   6
##         7    0   2   1   0   0   1   6 139   2  18   2  14
##         8    0   0   0   0   0   0   0   1  75  67  18  11
##         9    2   1   0   0   0   0   0   0  14 259  60  23
##         10   1   0   0   0   0   0   0   0   0  37 131  34
##         11   0   0   0   0   0   0   0   0   0   0  25  51
##
## Overall Statistics
##
##                Accuracy : 0.6859
##                  95% CI : (0.6673, 0.7041)
##     No Information Rate : 0.2296
##     P-Value [Acc > NIR] : < 2.2e-16
##
##                   Kappa : 0.6427
##
##  Mcnemar's Test P-Value : NA
##
## Statistics by Class:
##
##                      Class: 0 Class: 1 Class: 2 Class: 3 Class: 4 Class: 5
## Sensitivity           0.36364  0.24615  0.32450  0.49080  0.57143   0.9250
## Specificity           0.98975  0.95985  0.95736  0.97385  0.96799   0.9806
## Pos Pred Value        0.70000  0.25197  0.32886  0.56738  0.16842   0.8576
## Neg Pred Value        0.95944  0.95863  0.95654  0.96476  0.99500   0.9904
## Prevalence            0.06170  0.05208  0.06050  0.06530  0.01122   0.1122
## Detection Rate        0.02244  0.01282  0.01963  0.03205  0.00641   0.1038
## Detection Prevalence  0.03205  0.05088  0.05970  0.05649  0.03806   0.1210
## Balanced Accuracy     0.67669  0.60300  0.64093  0.73233  0.76971   0.9528
##                      Class: 6 Class: 7 Class: 8 Class: 9 Class: 10 Class: 11
## Sensitivity            0.9860  0.97887  0.81522   0.6574   0.54583   0.34228
## Specificity            0.9782  0.98046  0.95965   0.9524   0.96809   0.98935
## Pos Pred Value         0.9308  0.75135  0.43605   0.7214   0.64532   0.67105
## Neg Pred Value         0.9958  0.99870  0.99269   0.9368   0.95246   0.95950
## Prevalence             0.2296  0.05689  0.03686   0.1579   0.09615   0.05970
## Detection Rate         0.2264  0.05569  0.03005   0.1038   0.05248   0.02043
## Detection Prevalence   0.2432  0.07412  0.06891   0.1438   0.08133   0.03045
## Balanced Accuracy      0.9821  0.97967  0.88743   0.8049   0.75696   0.66581
```

Data Set two The Pokedex

Import second dataset the ultimate Pokedex. containing over 1000 pokemon entries.

```
pokemon_df<-read.csv("https://raw.githubusercontent.com/TheSaltyCrab/Data-622/main/pokemon.csv")

#pokemon_trim

unique(pokemon_df$type1)
```

```
##  [1] "Grass"     "Fire"      "Water"     "Blastoise" "Bug"       "Normal"
##  [7] "Dark"      "Poison"    "Electric"  "Ground"    "Ice"       "Fairy"
## [13] "Steel"     "Fighting"  "Psychic"   "Rock"      "Ghost"     "Dragon"
## [19] "Flying"    "Graass"
```

```
length(unique(pokemon_df$type1))
```

```
## [1] 20
```

Data exploration

Replace miss labeled data points.and run summary statistics

```
pokemon_df$type1[pokemon_df$type1=='Blastoise']<-'Water'
pokemon_df$type1[pokemon_df$type1=='Graass']<-'Grass'

pokemon_df<- pokemon_df%>%mutate(type=case_when(type1=="Grass"~1,type1=="Fire"~2,type1=="Water"~3, type

pokemon_trim<-pokemon_df %>%
  select(!c(name,type2,number,legendary))
#unique(pokemon_df$type1)
#length(unique(pokemon_df$type1))
#summary(pokemon_trim)

summary(pokemon_trim)
```

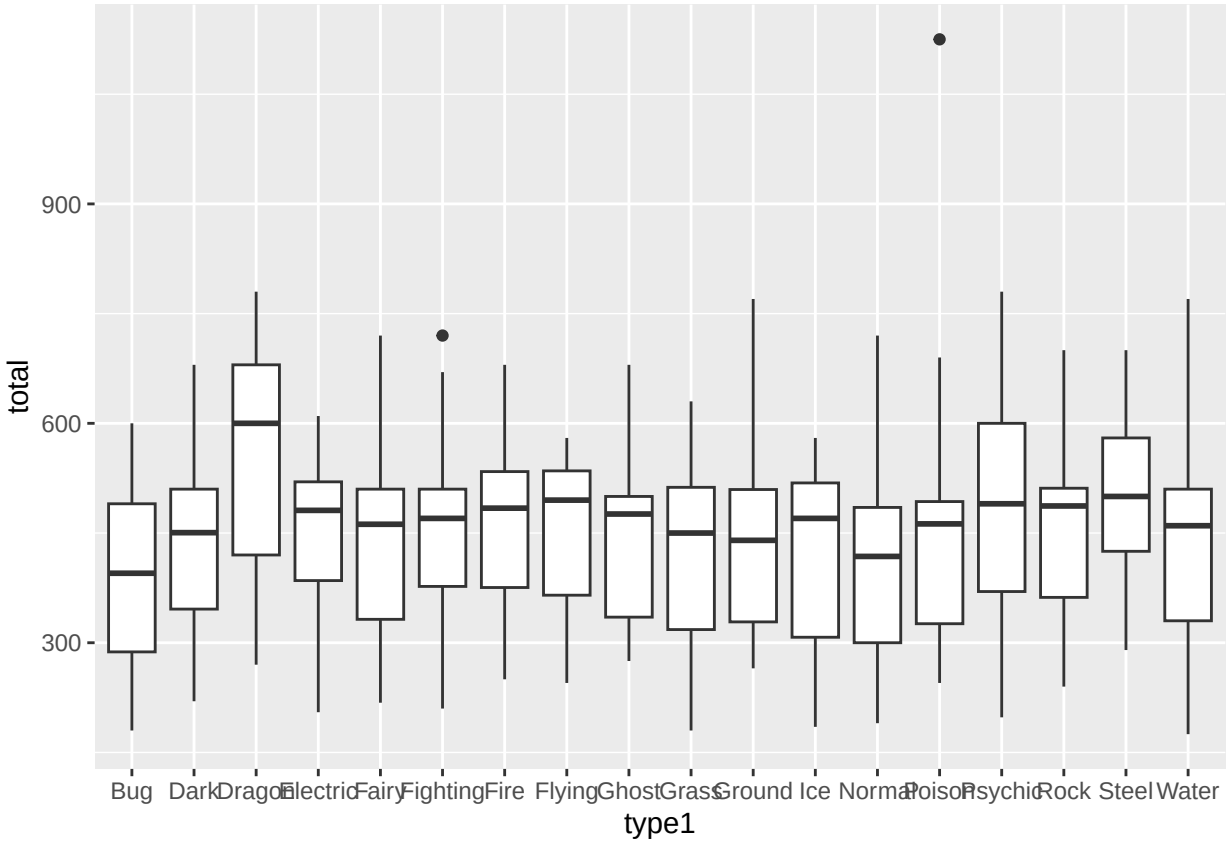
```
##     type1               total             hp              attack
##  Length:1072        Min.   : 175.0   Min.   :  1.00   Min.   :  5.00
##  Class :character   1st Qu.: 330.0   1st Qu.: 50.00   1st Qu.: 56.00
##  Mode  :character   Median : 460.5   Median : 68.00   Median : 80.00
##                     Mean   : 440.9   Mean   : 70.49   Mean   : 80.94
##                     3rd Qu.: 519.2   3rd Qu.: 84.00   3rd Qu.:100.00
##                     Max.   :1125.0   Max.   :255.00   Max.   :190.00
##     defense          sp_attack        sp_defense         speed
##  Min.   :  5.00   Min.   : 10.00   Min.   : 20.00   Min.   :  5.00
##  1st Qu.: 52.00   1st Qu.: 50.00   1st Qu.: 50.00   1st Qu.: 45.00
##  Median : 70.00   Median : 65.00   Median : 70.00   Median : 65.00
##  Mean   : 74.97   Mean   : 73.27   Mean   : 72.48   Mean   : 68.79
```

```
##  3rd Qu.: 90.00   3rd Qu.: 95.00   3rd Qu.: 90.00   3rd Qu.: 90.00
##  Max.   :250.00   Max.   :194.00   Max.   :250.00   Max.   :200.00
##    generation         type
##  Min.   :0.000   Min.   : 1.000
##  1st Qu.:2.000   1st Qu.: 3.000
##  Median :4.000   Median : 6.000
##  Mean   :4.295   Mean   : 7.718
##  3rd Qu.:6.000   3rd Qu.:13.000
##  Max.   :8.000   Max.   :18.000
```

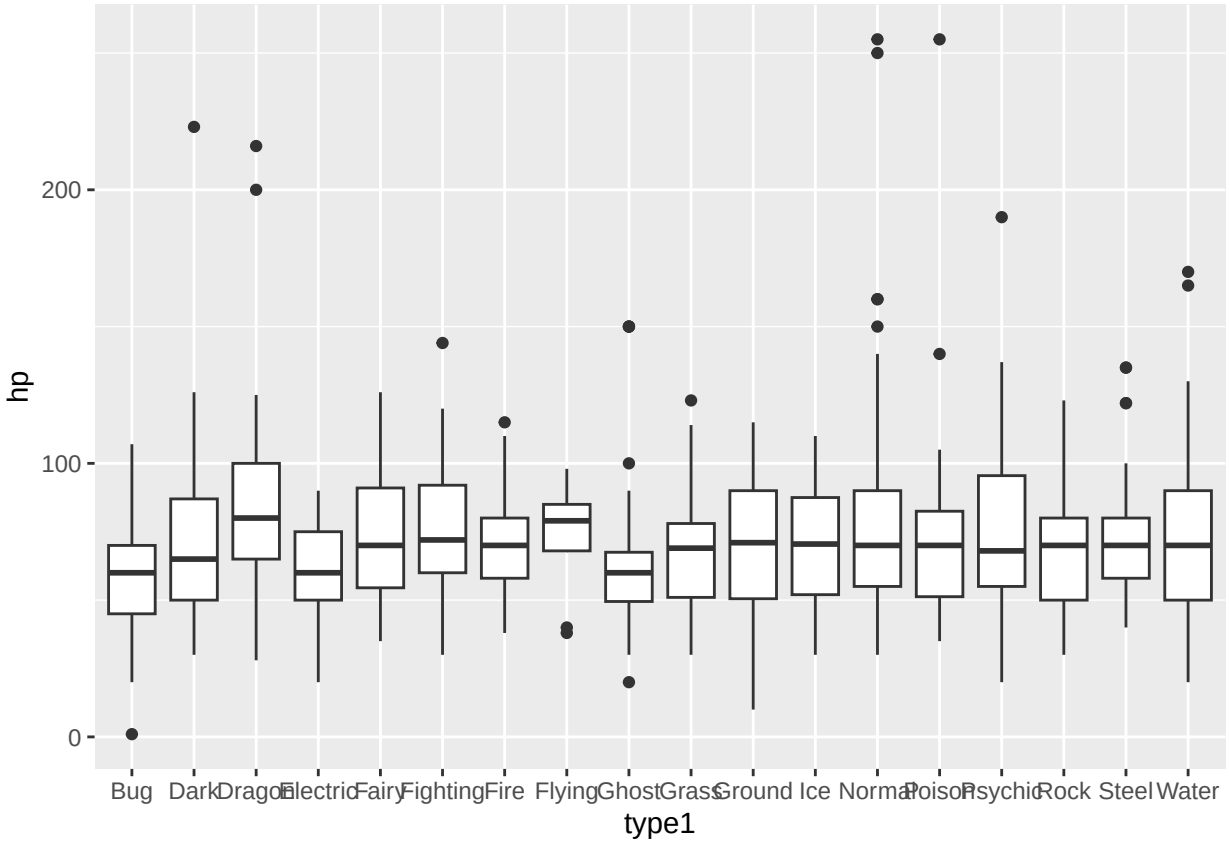
```
#pokemon_df$type
```

plots for each stat type sorted by type

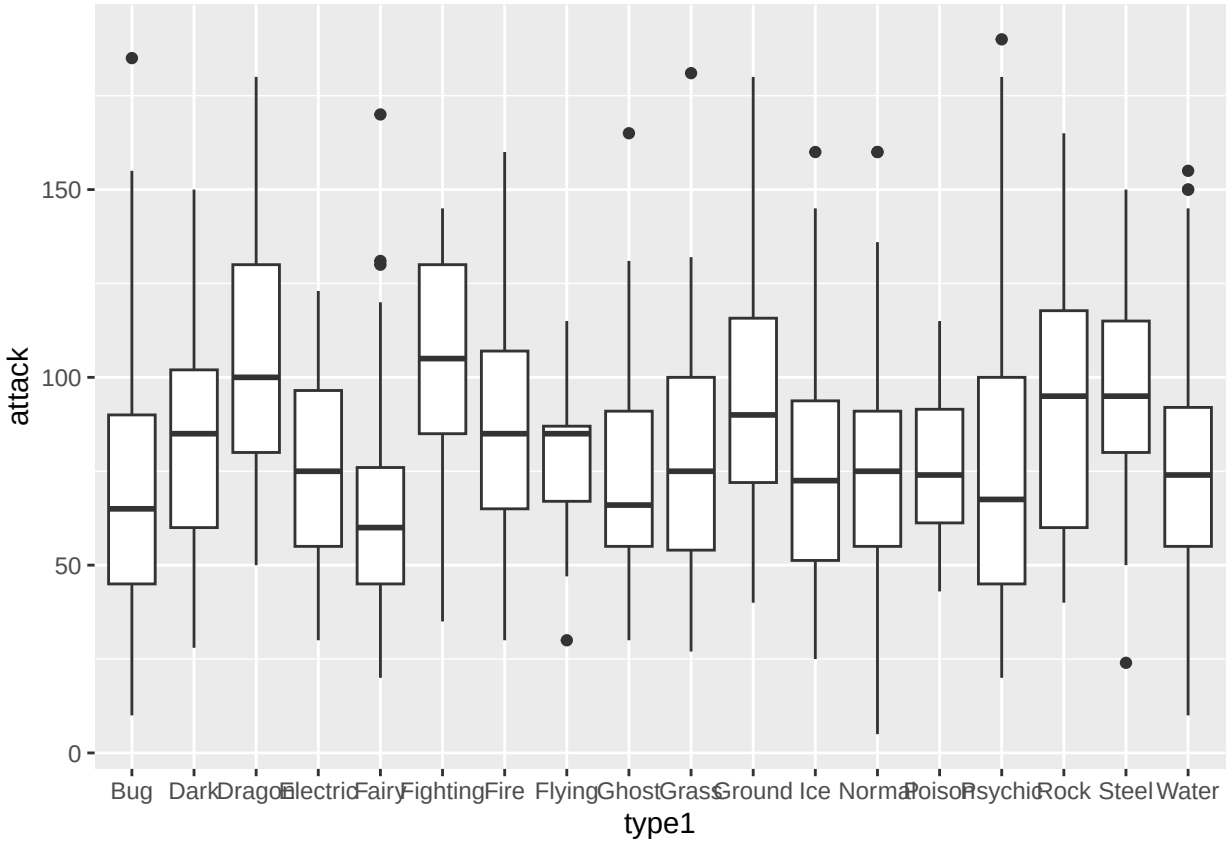
```
#ggplot(air_q, aes(x=as.character(Week_Day), y=PM_2_5_24_Hour_Avg_)) +
#  geom_boxplot()
p1=ggplot(pokemon_trim, aes(x=type1, y=total)) +
  geom_boxplot()
p2=ggplot(pokemon_trim, aes(x=type1, y=hp)) +
  geom_boxplot()
p3=ggplot(pokemon_trim, aes(x=type1, y=attack)) +
  geom_boxplot()
p4=ggplot(pokemon_trim, aes(x=type1, y=defense)) +
  geom_boxplot()
p5=ggplot(pokemon_trim, aes(x=type1, y=sp_attack)) +
  geom_boxplot()
p6=ggplot(pokemon_trim, aes(x=type1, y=sp_defense)) +
  geom_boxplot()
p7=ggplot(pokemon_trim, aes(x=type1, y=speed)) +
  geom_boxplot()
p8=ggplot(pokemon_trim, aes(x=as.character(generation), y=total)) +
  geom_boxplot()
p9=ggplot(pokemon_trim, aes(x=type1, y=generation)) +
  geom_boxplot()
p1
```


900
600
300
total
Bug
Dark
Dragon
Electric
Fairy
Fighting
Fire
Flying
Ghost
Grass
Ground
Ice
Normal
Poison
Psychic
Rock
Steel
Water
type1

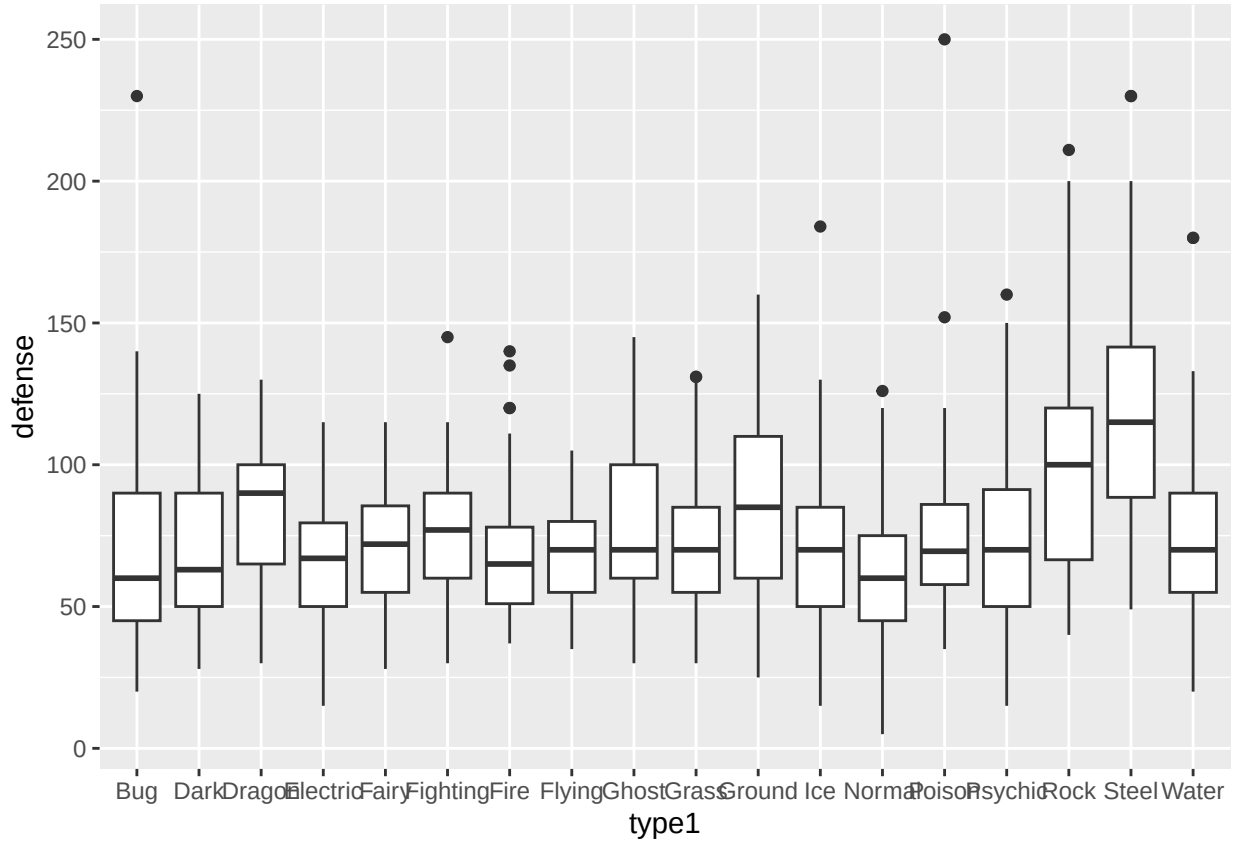
```
p2
```


200
100
0
hp
Bug
Dark
Dragon
Electric
Fairy
Fighting
Fire
Flying
Ghost
Grass
Ground
Ice
Normal
Poison
Psychic
Rock
Steel
Water
type1

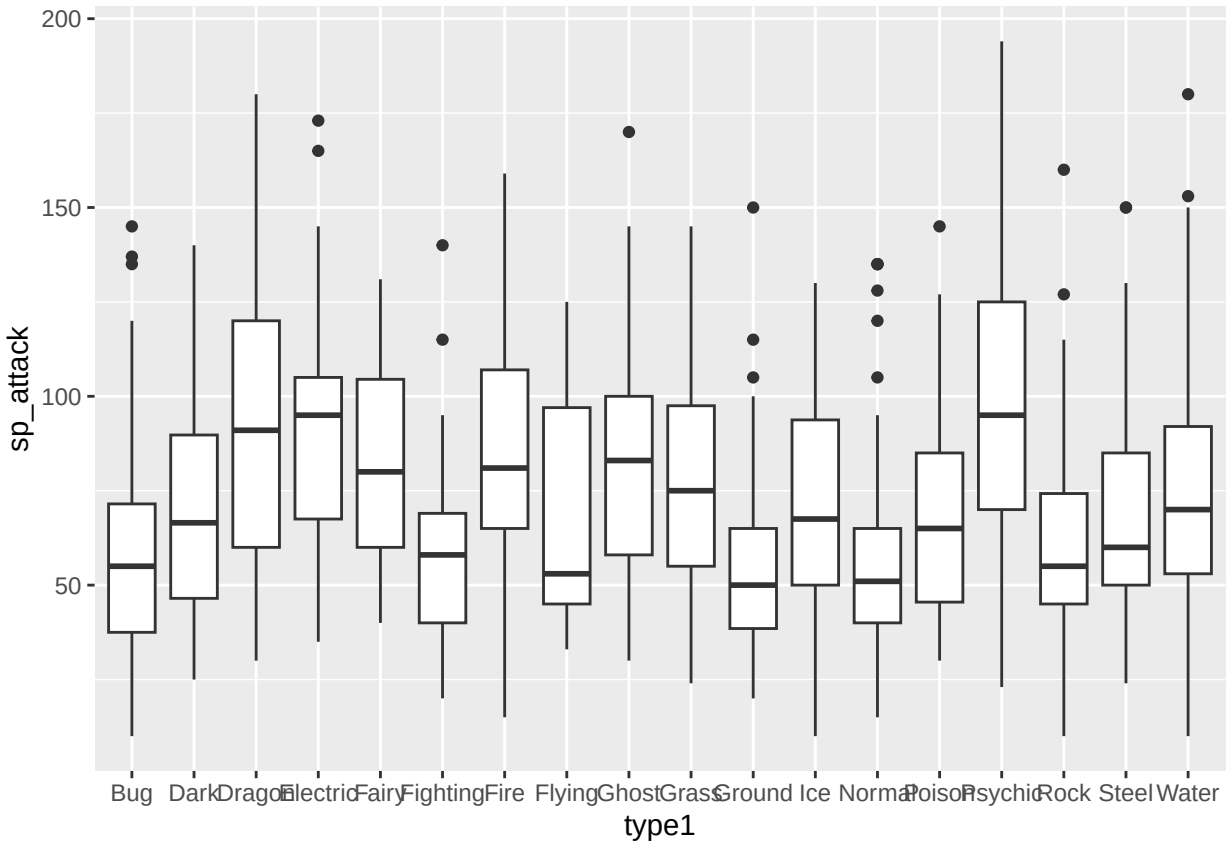
```
p3
```


attack
150
100
50
0
Bug
Dark
Dragon
Electric
Fairy
Fighting
Fire
Flying
Ghost
Grass
Ground
Ice
Normal
Poison
Psychic
Rock
Steel
Water
type1

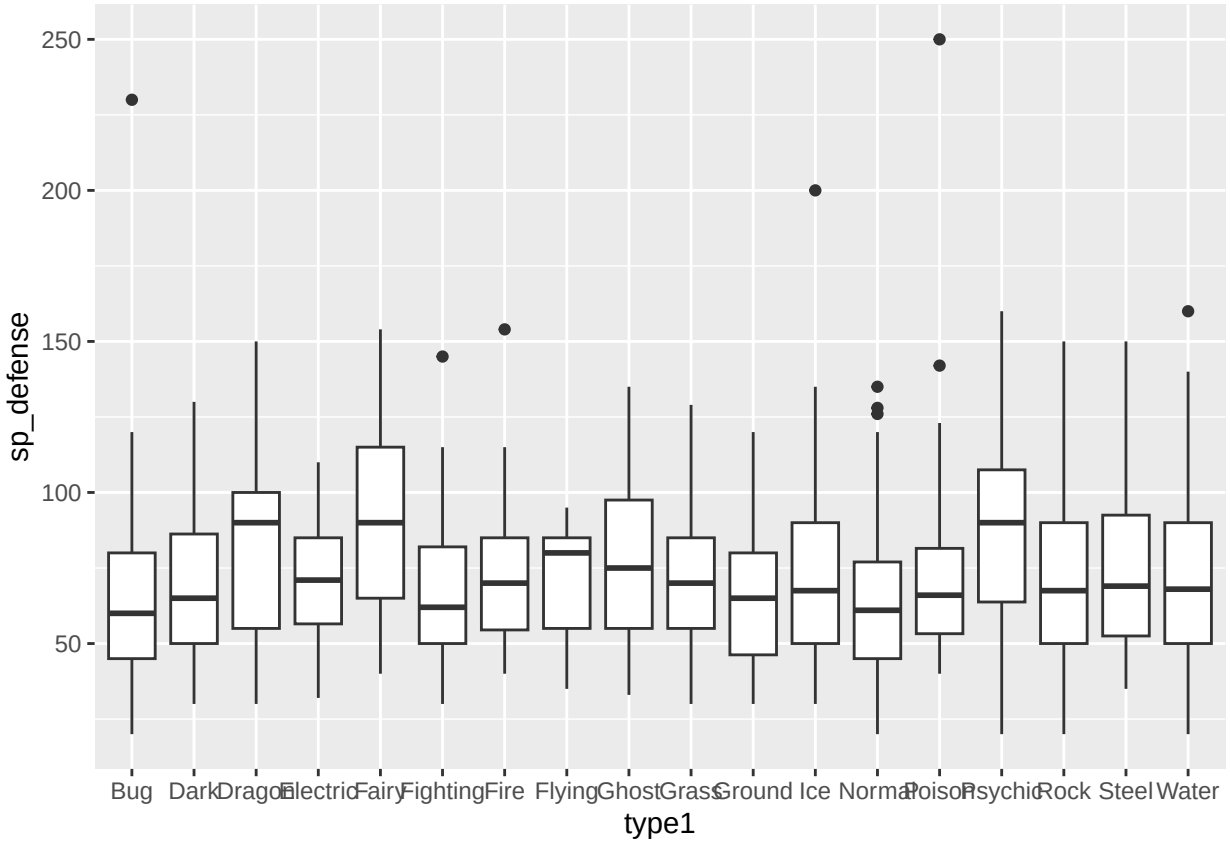
```
p4
```


250
200
150
100
50
0
defense
Bug
Dark
Dragon
Electric
Fairy
Fighting
Fire
Flying
Ghost
Grass
Ground
Ice
Normal
Poison
Psychic
Rock
Steel
Water
type1

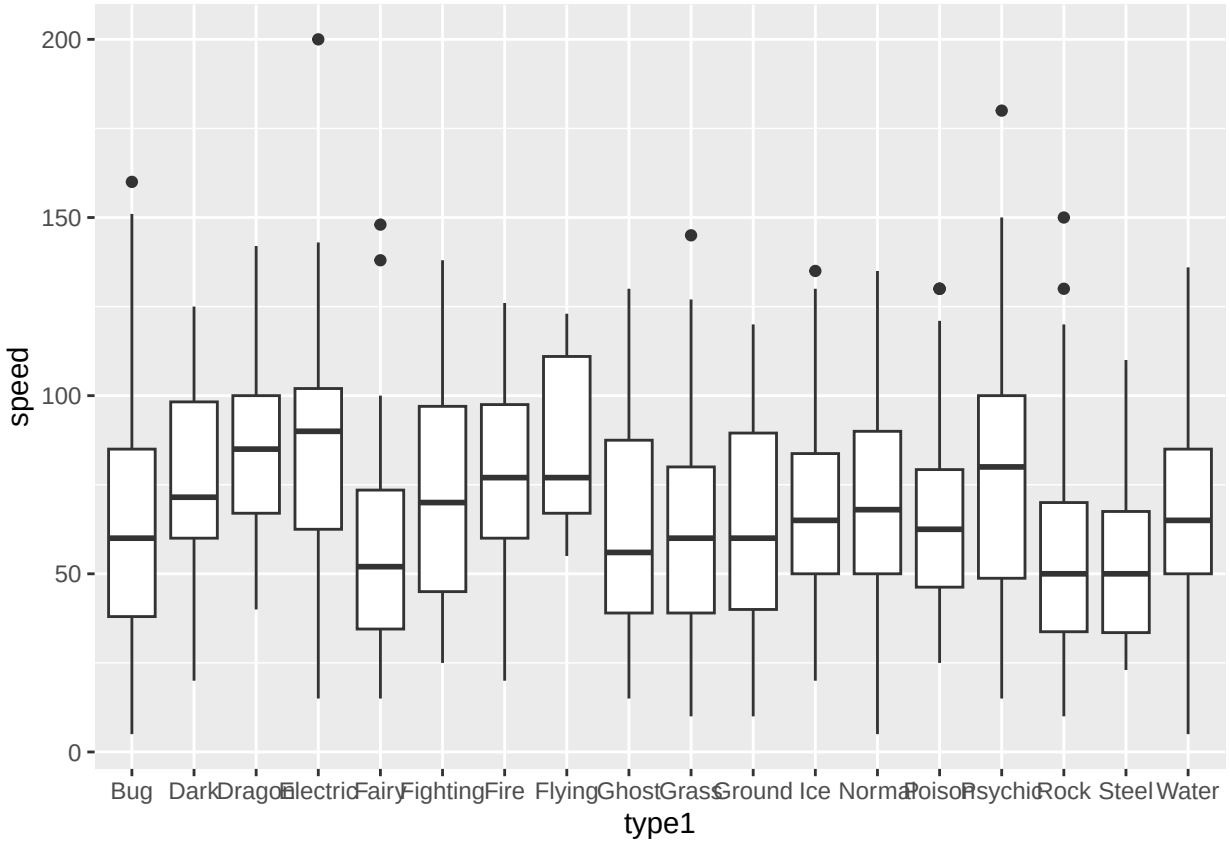
```
p5
```


200
150
100
50
sp_attack
Bug
Dark
Dragon
Electric
Fairy
Fighting
Fire
Flying
Ghost
Grass
Ground
Ice
Normal
Poison
Psychic
Rock
Steel
Water
type1

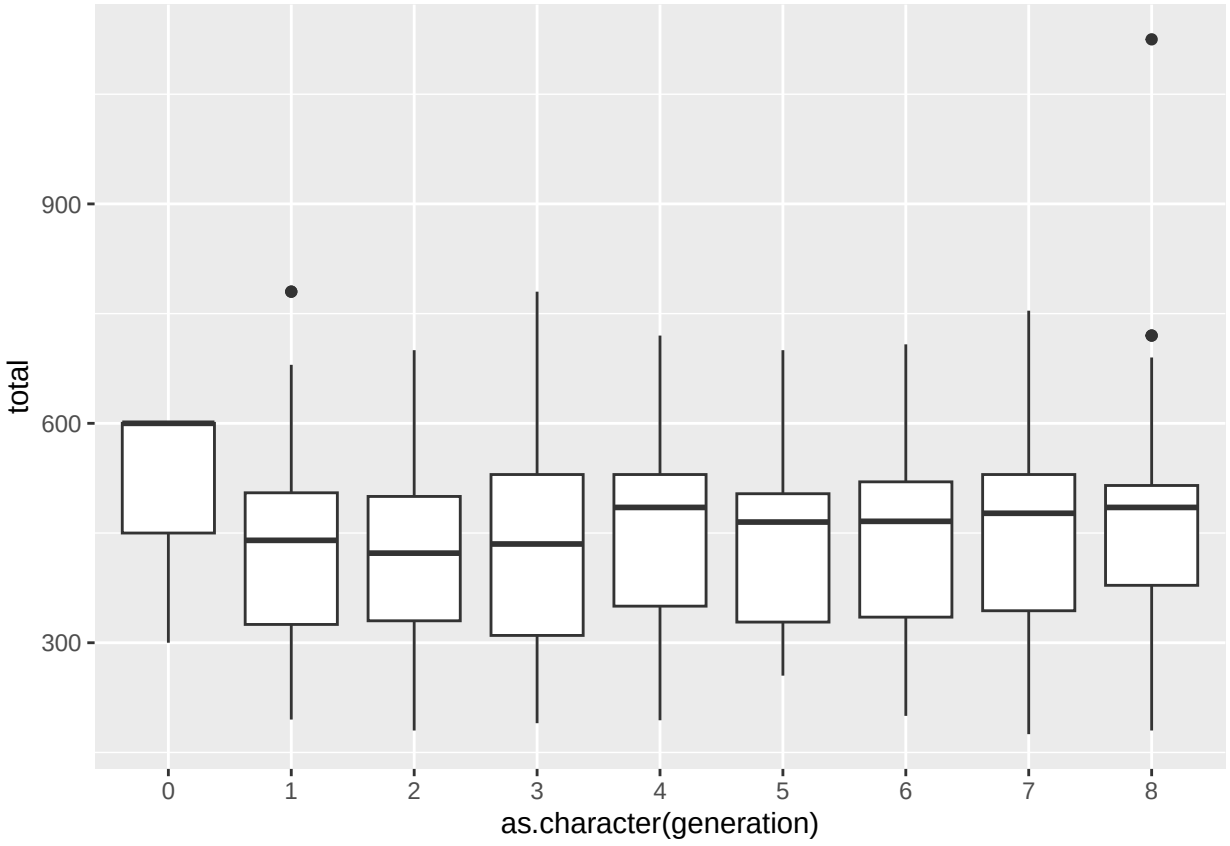
```
p6
```


250
200
150
100
50
sp_defense
Bug
Dark
Dragon
Electric
Fairy
Fighting
Fire
Flying
Ghost
Grass
Ground
Ice
Normal
Poison
Psychic
Rock
Steel
Water
type1

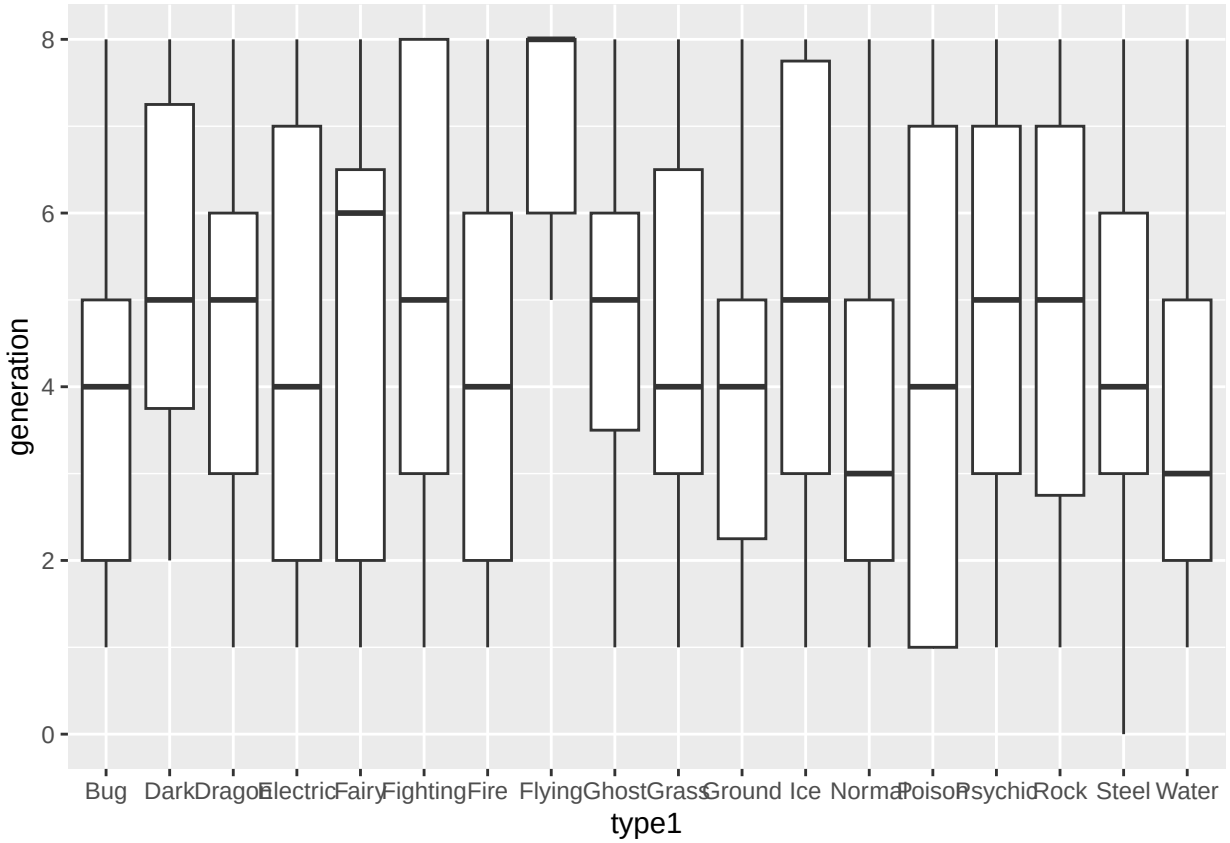
```
p7
```


200
150
100
50
0
speed
Bug
Dark
Dragon
Electric
Fairy
Fighting
Fire
Flying
Ghost
Grass
Ground
Ice
Normal
Poison
Psychic
Rock
Steel
Water
type1

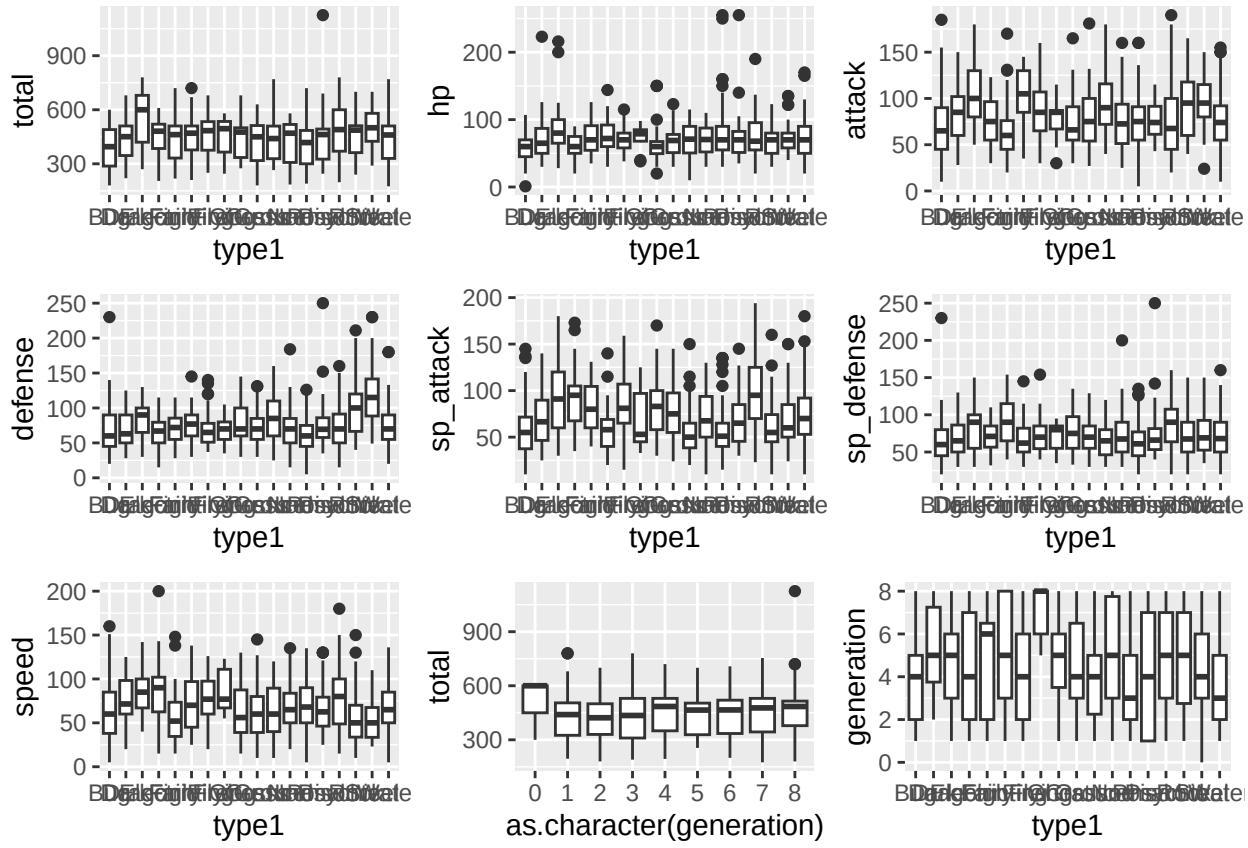
```
p8
```




```
p9
```




```
grid.arrange(p1,p2,p3,p4,p5,p6,p7,p8,p9)
```




```
pokemon_df[pokemon_trim$generation==0,]
```

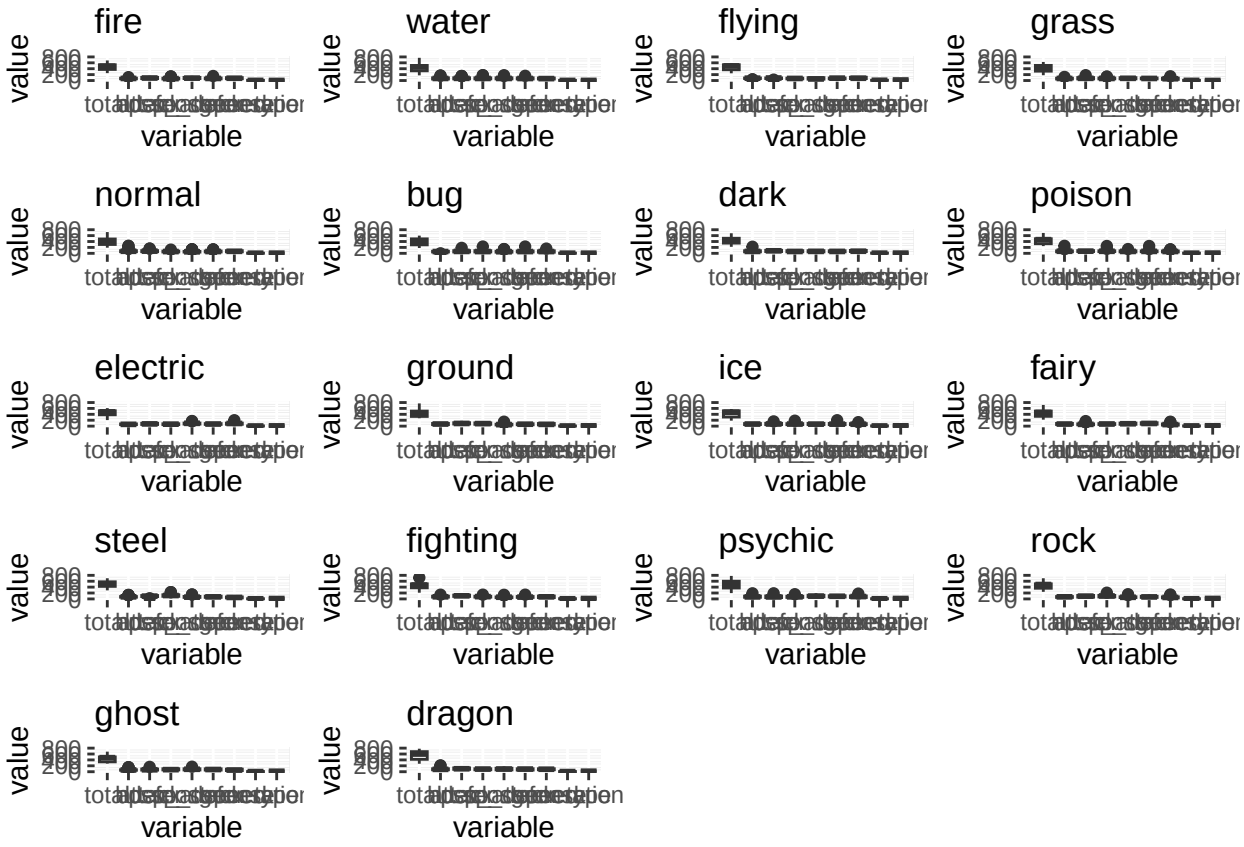
```
##     number                name type1 type2 total  hp attack defense sp_attack
## 951    808              Meltan Steel         300  46     65      65        55
## 952    809            Melmetal Steel         600 135    143     143        80
## 953    809 Gigantamax Melmetal Steel         600 135    143     143        80
##     sp_defense speed generation legendary type
## 951         35    34          0      True   12
## 952         65    34          0      True   12
## 953         65    34          0      True   12
```

```
dat_m <- melt(pokemon_trim, id.vars = "type1")
#head(dat_m,50)

# plot data
fire<-dat_m[dat_m$type1=="Fire",]
water<-dat_m[dat_m$type1=="Water",]
flying<-dat_m[dat_m$type1=="Flying",]
grass<-dat_m[dat_m$type1=="Grass",]
normal<-dat_m[dat_m$type1=="Normal",]
bug<-dat_m[dat_m$type1=="Bug",]
dark<-dat_m[dat_m$type1=="Dark",]
poison<-dat_m[dat_m$type1=="Poison",]
electric<-dat_m[dat_m$type1=="Electric",]
ground<-dat_m[dat_m$type1=="Ground",]
```

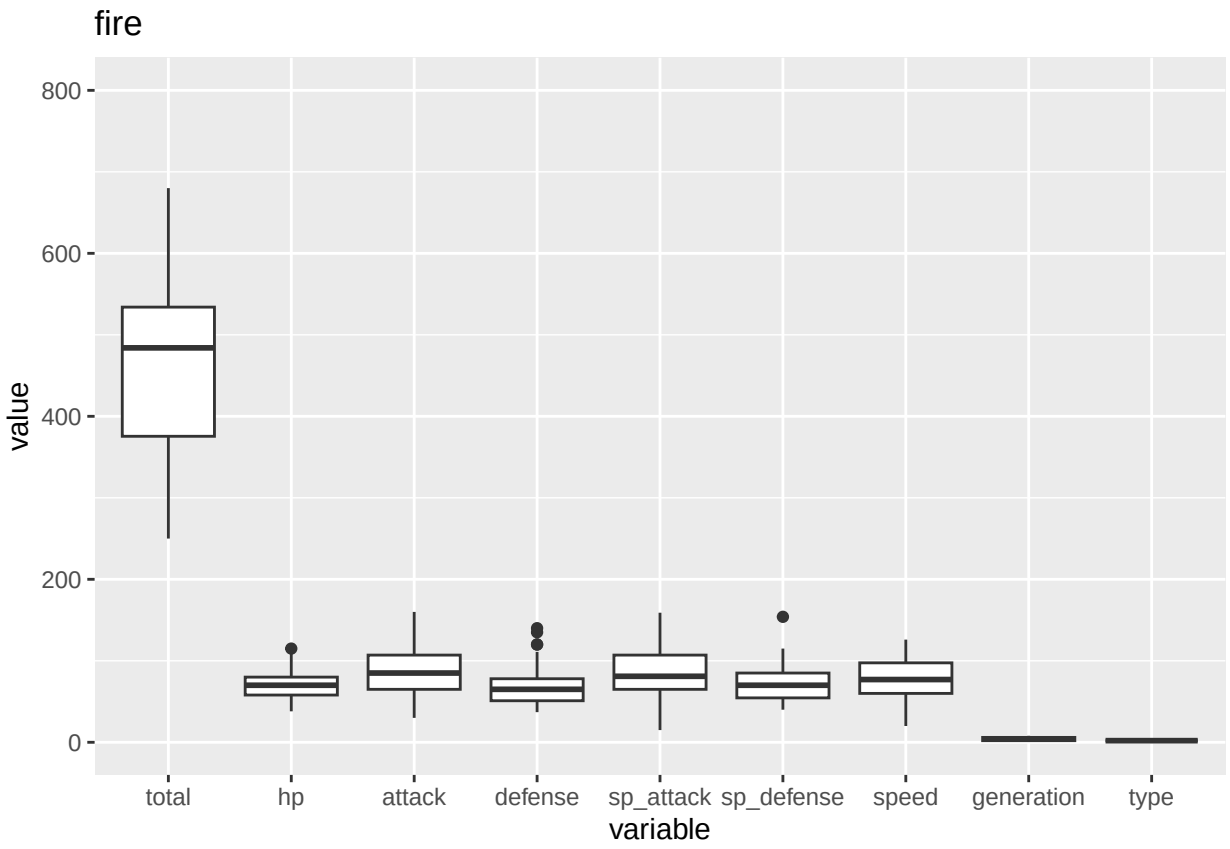
```
ice<-dat_m[dat_m$type1=="Ice",]
fairy<-dat_m[dat_m$type1=="Fairy",]
steel<-dat_m[dat_m$type1=="Steel",]
fighting<-dat_m[dat_m$type1=="Fighting",]
psychic<-dat_m[dat_m$type1=="Psychic",]
rock<-dat_m[dat_m$type1=="Rock",]
ghost<-dat_m[dat_m$type1=="Ghost",]
dragon<-dat_m[dat_m$type1=="Dragon",]
fir<-ggplot(fire, aes(x=variable, y=value)) +
  geom_boxplot()+coord_cartesian(ylim = c(0, 800))+ggtitle("fire")
wat<-ggplot(water, aes(x=variable, y=value)) +
  geom_boxplot()+coord_cartesian(ylim = c(0, 800))+ggtitle("water")
fly<-ggplot(flying, aes(x=variable, y=value)) +
  geom_boxplot()+coord_cartesian(ylim = c(0, 800))+ggtitle("flying")
gra<-ggplot(grass, aes(x=variable, y=value)) +
  geom_boxplot()+coord_cartesian(ylim = c(0, 800))+ggtitle("grass")
nor<-ggplot(normal, aes(x=variable, y=value)) +
  geom_boxplot()+coord_cartesian(ylim = c(0, 800))+ggtitle("normal")
g_bug<-ggplot(bug, aes(x=variable, y=value)) +
  geom_boxplot()+coord_cartesian(ylim = c(0, 800))+ggtitle("bug")
dar<-ggplot(dark, aes(x=variable, y=value)) +
  geom_boxplot()+coord_cartesian(ylim = c(0, 800))+ggtitle("dark")
poi<-ggplot(poison, aes(x=variable, y=value)) +
  geom_boxplot()+coord_cartesian(ylim = c(0, 800))+ggtitle("poison")
ele<-ggplot(electric, aes(x=variable, y=value)) +
  geom_boxplot()+coord_cartesian(ylim = c(0, 800))+ggtitle("electric")
gro<-ggplot(ground, aes(x=variable, y=value)) +
  geom_boxplot()+coord_cartesian(ylim = c(0, 800))+ggtitle("ground")
g_ice<-ggplot(ice, aes(x=variable, y=value)) +
  geom_boxplot()+coord_cartesian(ylim = c(0, 800))+ggtitle("ice")
fai<-ggplot(fairy, aes(x=variable, y=value)) +
  geom_boxplot()+coord_cartesian(ylim = c(0, 800))+ggtitle("fairy")
ste<-ggplot(steel, aes(x=variable, y=value)) +
  geom_boxplot()+coord_cartesian(ylim = c(0, 800))+ggtitle("steel")
fig<-ggplot(fighting, aes(x=variable, y=value)) +
  geom_boxplot()+coord_cartesian(ylim = c(0, 800))+ggtitle("fighting")
psy<-ggplot(psychic, aes(x=variable, y=value)) +
  geom_boxplot()+coord_cartesian(ylim = c(0, 800))+ggtitle("psychic")
roc<-ggplot(rock, aes(x=variable, y=value)) +
  geom_boxplot()+coord_cartesian(ylim = c(0, 800))+ggtitle("rock")
gho<-ggplot(ghost, aes(x=variable, y=value)) +
  geom_boxplot()+coord_cartesian(ylim = c(0, 800))+ggtitle("ghost")
dra<-ggplot(dragon, aes(x=variable, y=value)) +
  geom_boxplot()+coord_cartesian(ylim = c(0, 800))+ggtitle("dragon")

grid.arrange(fir,wat,fly,gra,nor,g_bug,dar,poi,ele,gro,g_ice,fai,ste,fig,psy,roc,gho,dra)
```

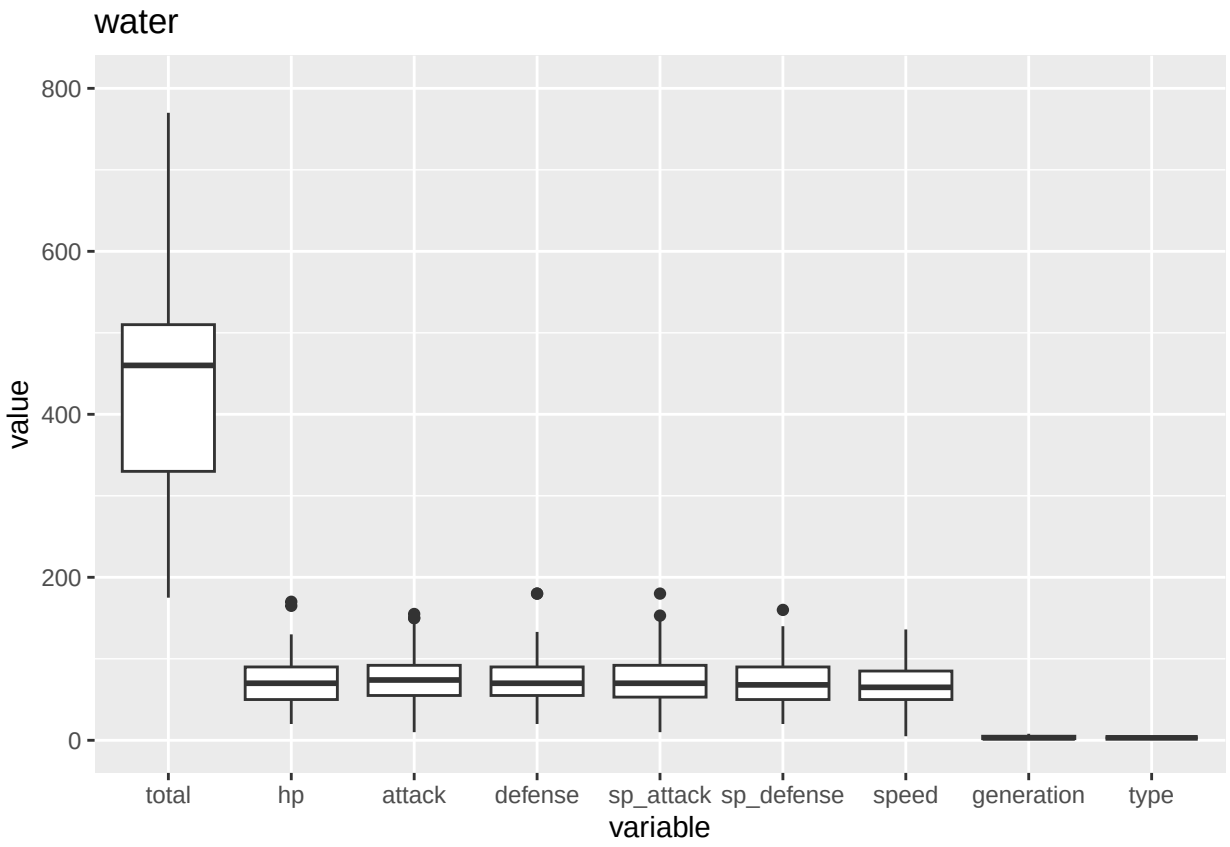


plots for each type sorted by stats

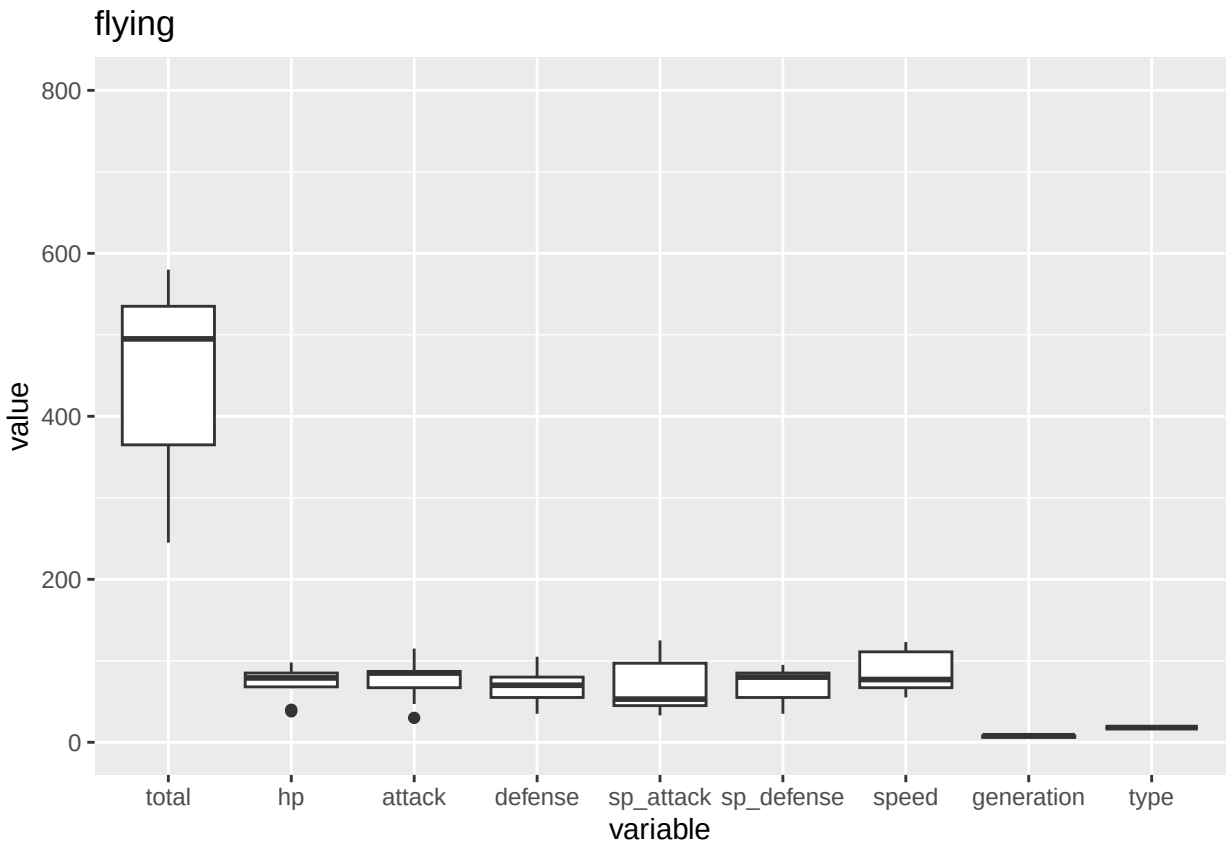
```
ggplot(fire, aes(x=variable, y=value)) +
  geom_boxplot()+coord_cartesian(ylim = c(0, 800))+ggtitle("fire")
```



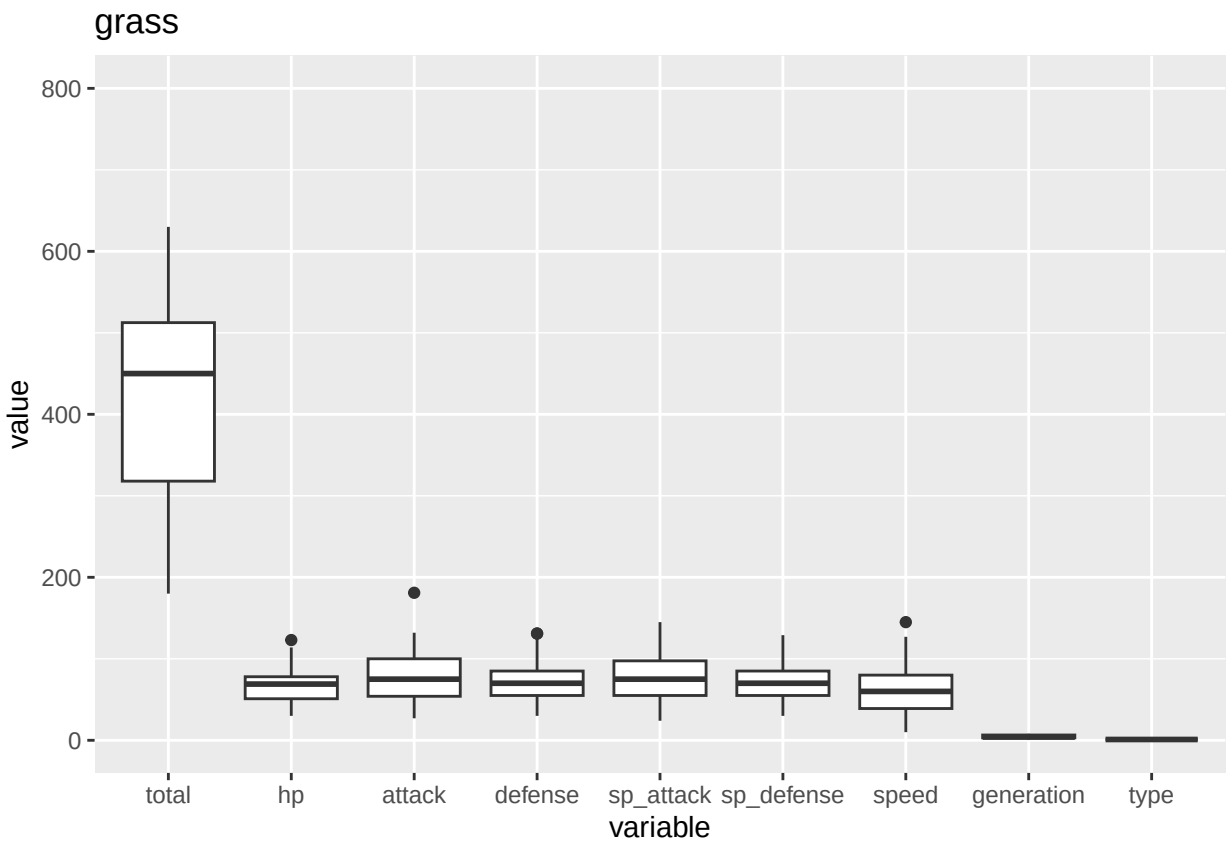

```
ggplot(water, aes(x=variable, y=value)) +
  geom_boxplot()+coord_cartesian(ylim = c(0, 800))+ggtitle("water")
```



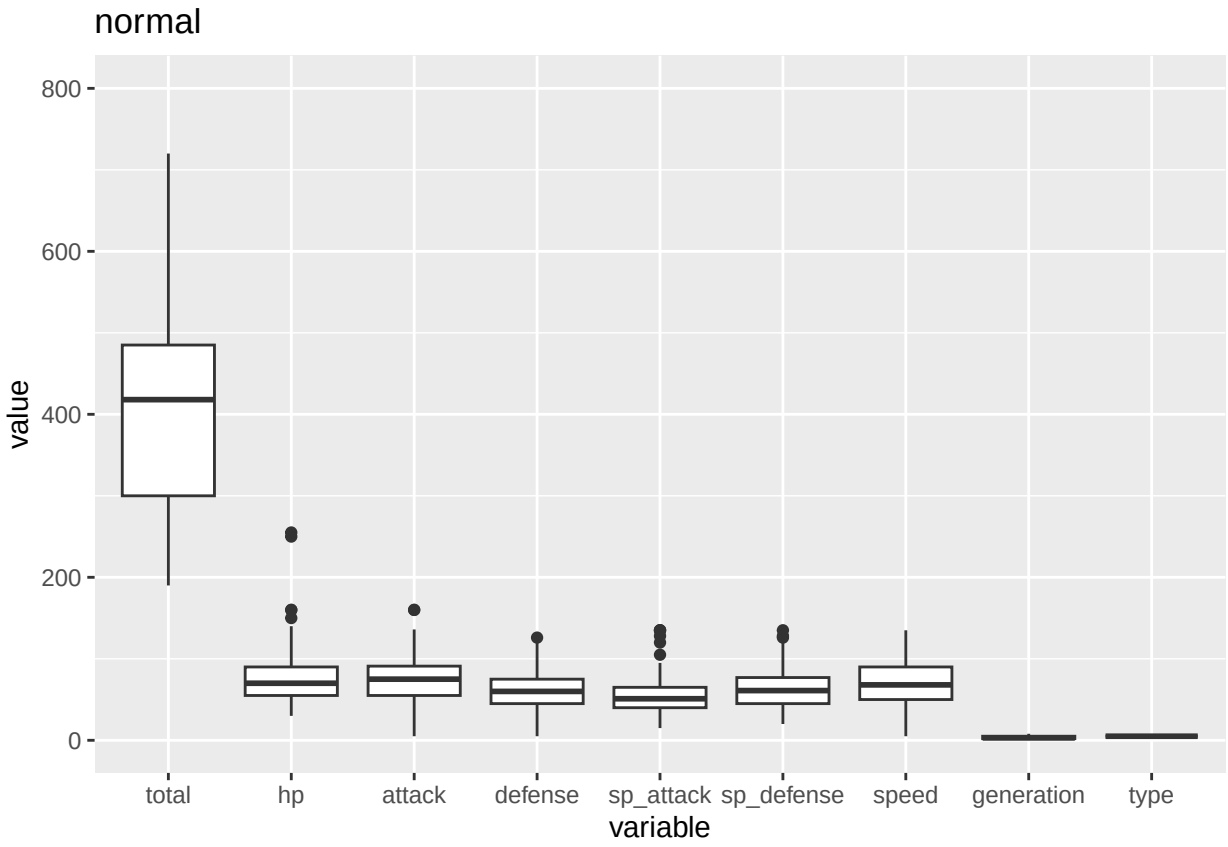

```
ggplot(flying, aes(x=variable, y=value)) +
  geom_boxplot()+coord_cartesian(ylim = c(0, 800))+ggtitle("flying")
```



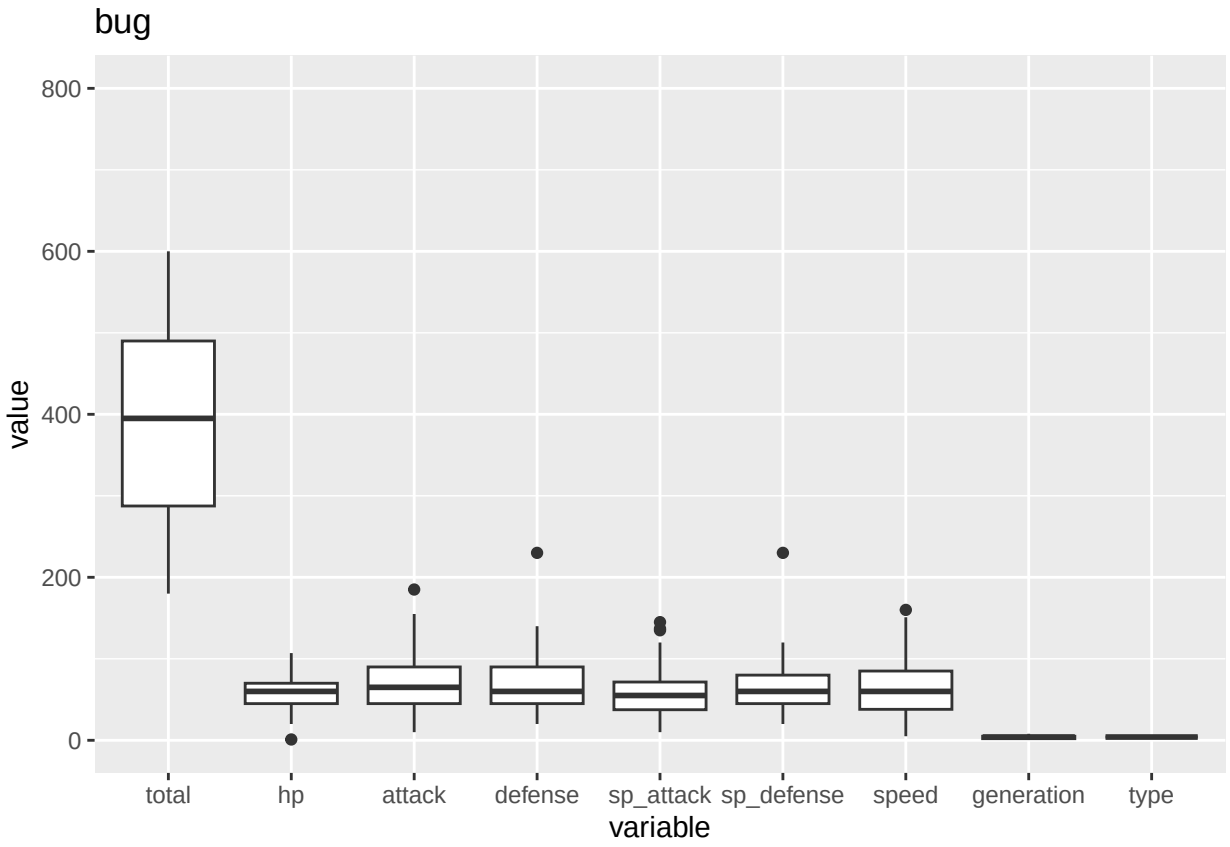

```
ggplot(grass, aes(x=variable, y=value)) +
  geom_boxplot()+coord_cartesian(ylim = c(0, 800))+ggtitle("grass")
```



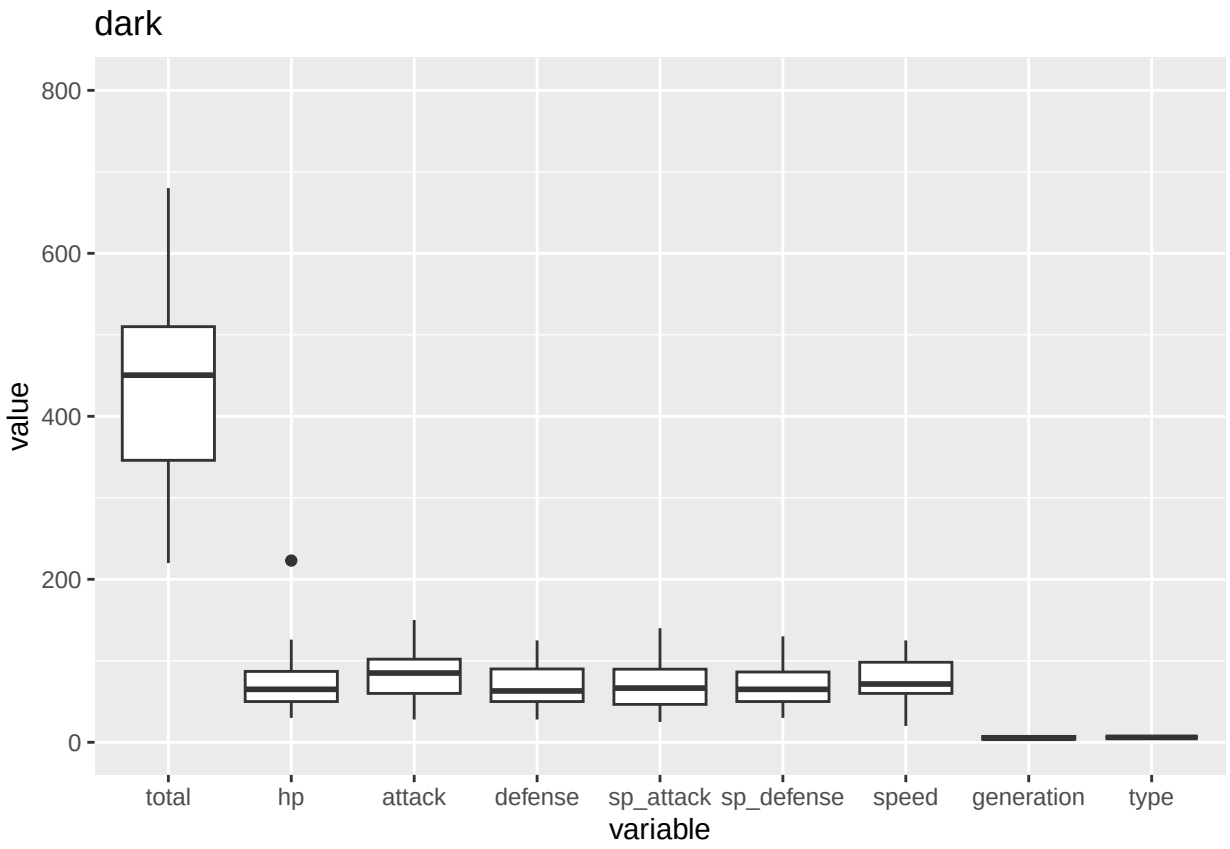

```
ggplot(normal, aes(x=variable, y=value)) +
  geom_boxplot()+coord_cartesian(ylim = c(0, 800))+ggtitle("normal")
```



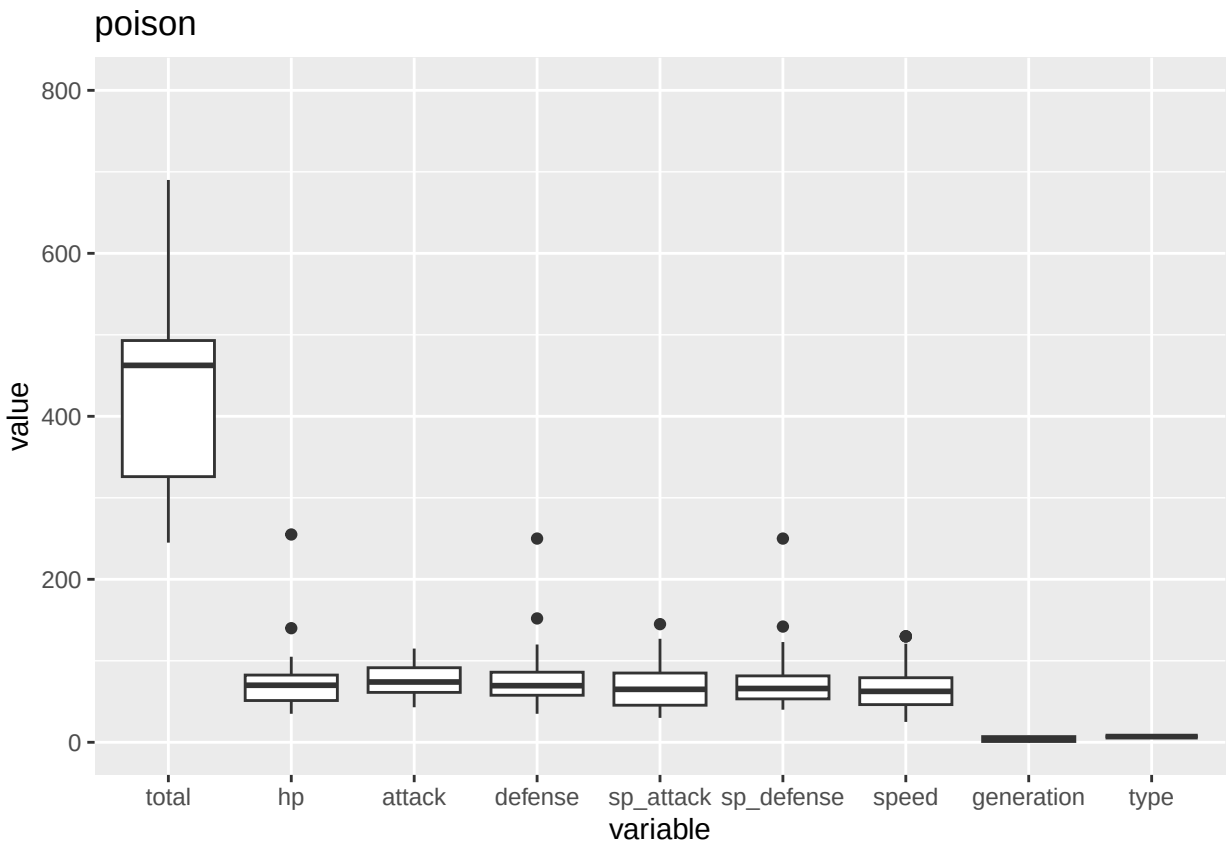

```
ggplot(bug, aes(x=variable, y=value)) +
  geom_boxplot()+coord_cartesian(ylim = c(0, 800))+ggtitle("bug")
```



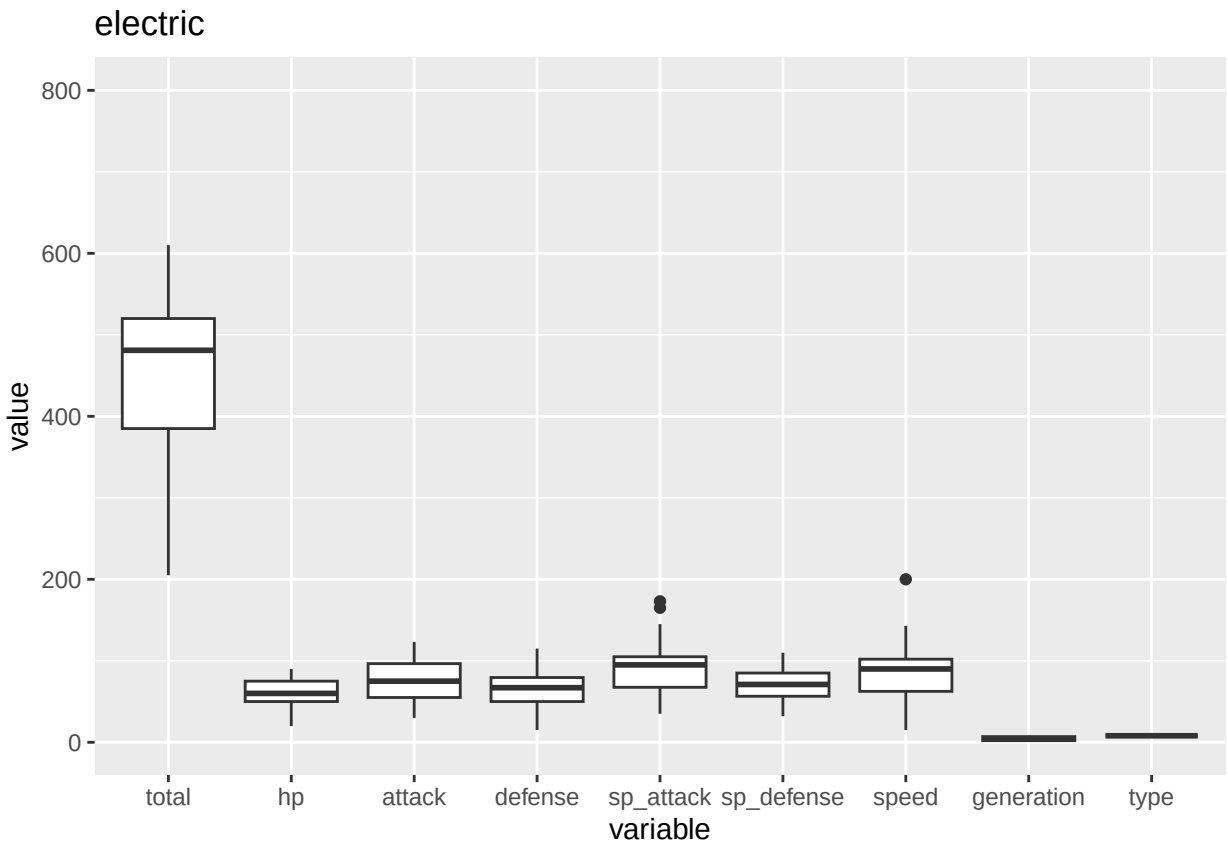

```
ggplot(dark, aes(x=variable, y=value)) +
  geom_boxplot()+coord_cartesian(ylim = c(0, 800))+ggtitle("dark")
```



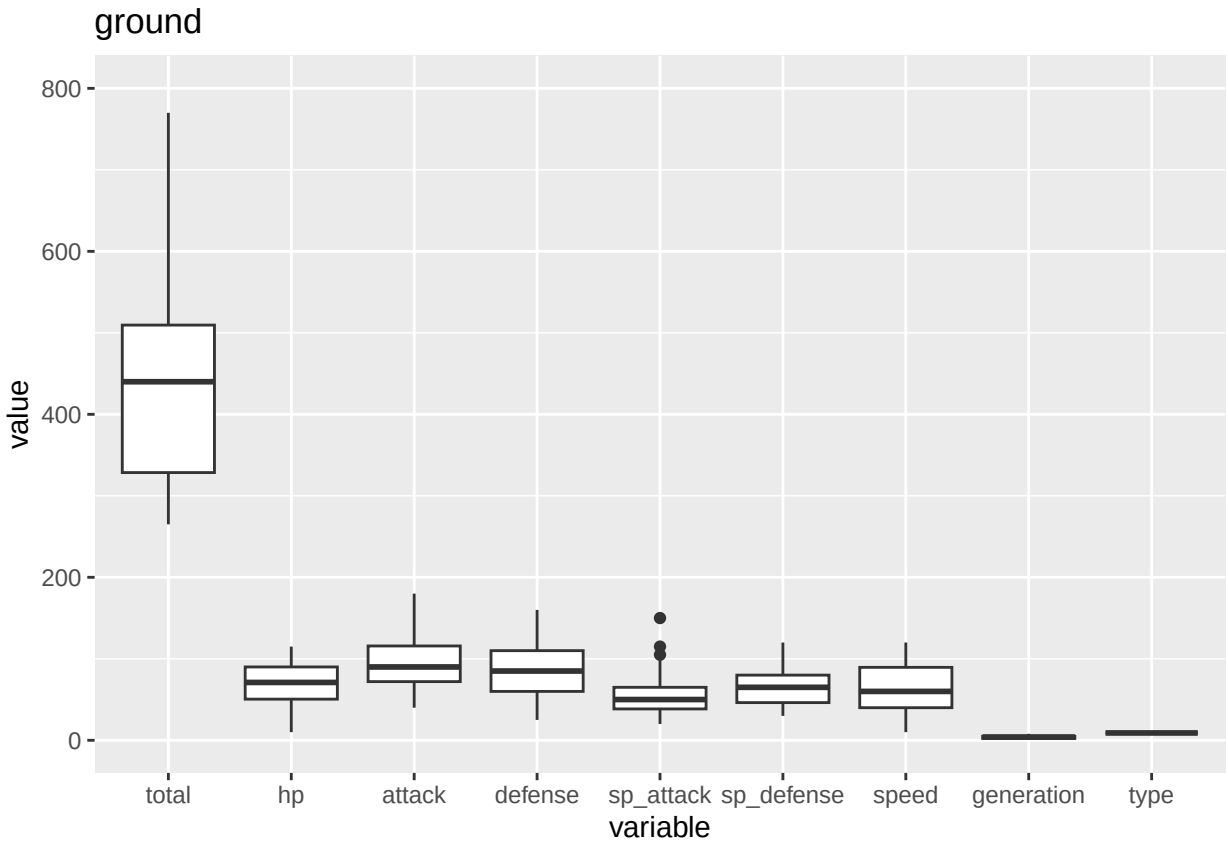

```
ggplot(poison, aes(x=variable, y=value)) +
  geom_boxplot()+coord_cartesian(ylim = c(0, 800))+ggtitle("poison")
```



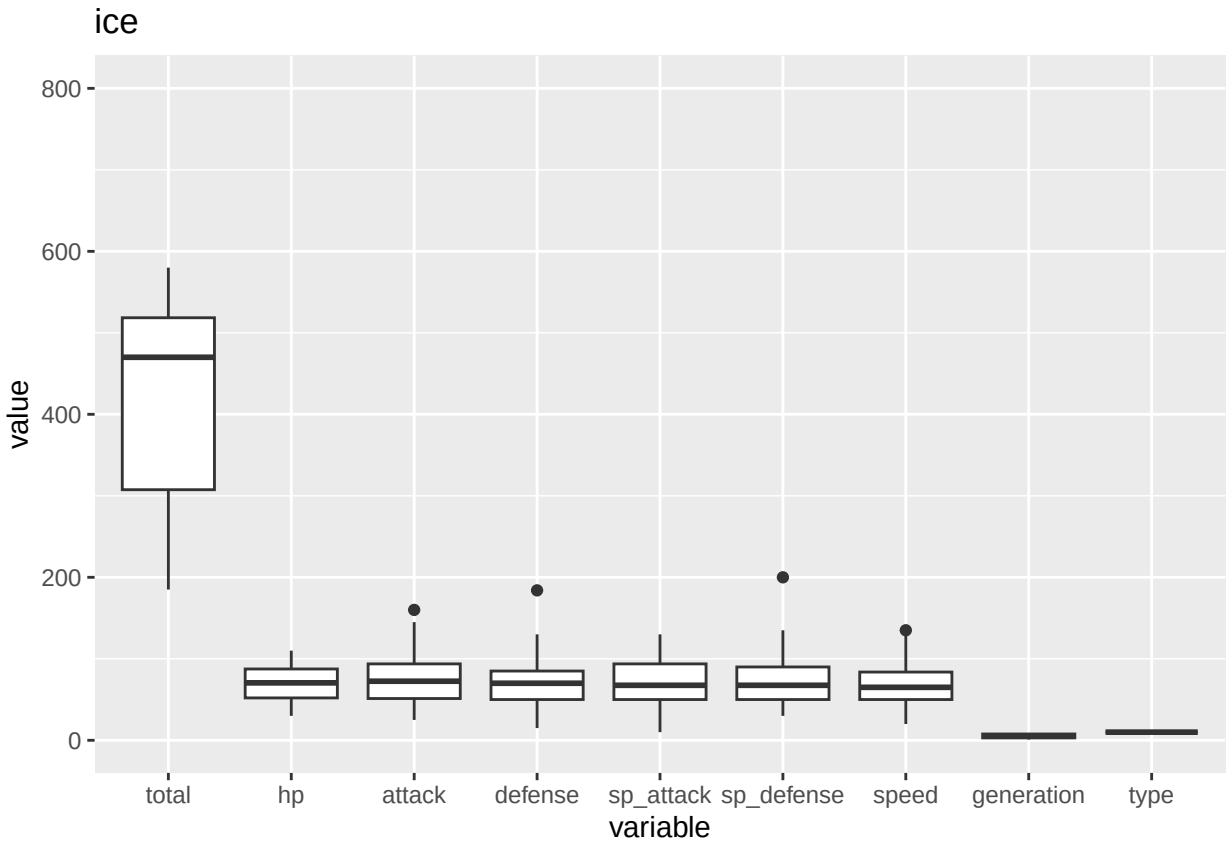

```
ggplot(electric, aes(x=variable, y=value)) +
  geom_boxplot()+coord_cartesian(ylim = c(0, 800))+ggtitle("electric")
```



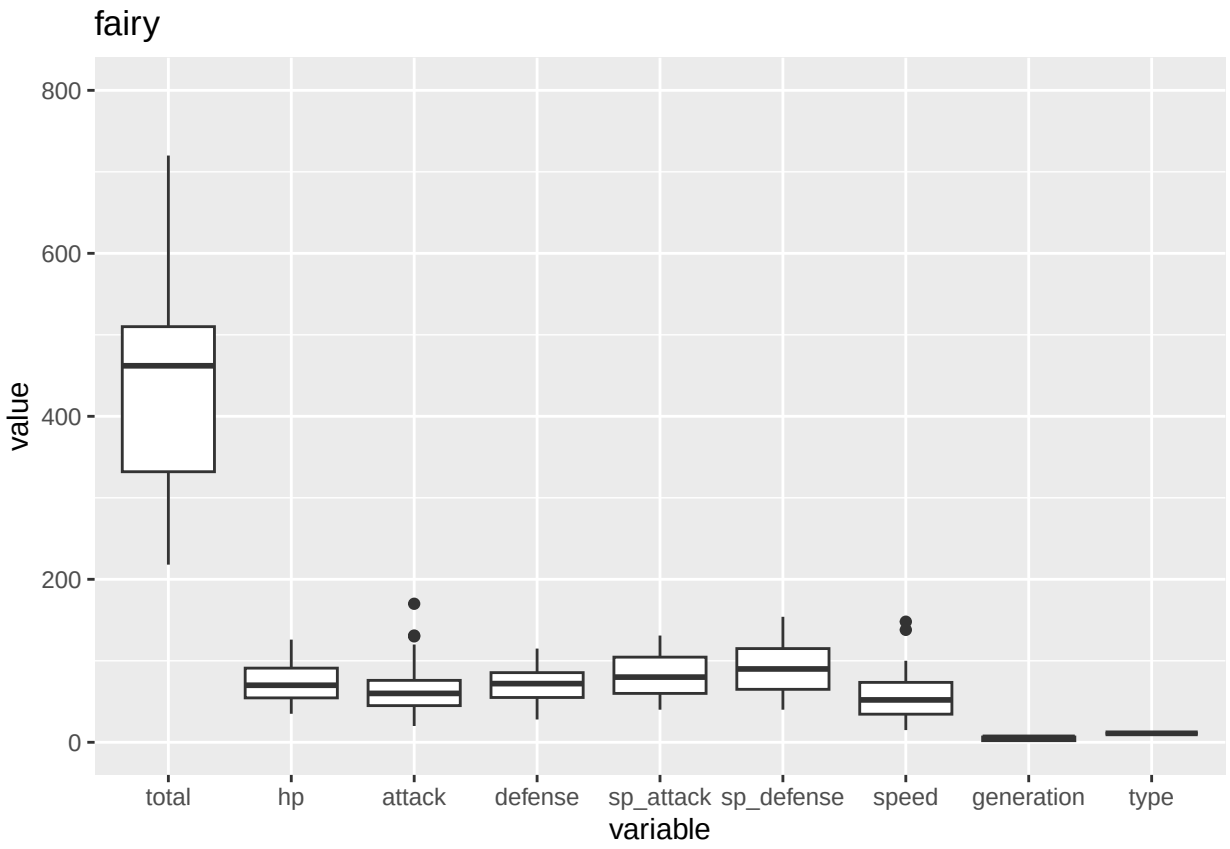

```
ggplot(ground, aes(x=variable, y=value)) +
  geom_boxplot()+coord_cartesian(ylim = c(0, 800))+ggtitle("ground")
```



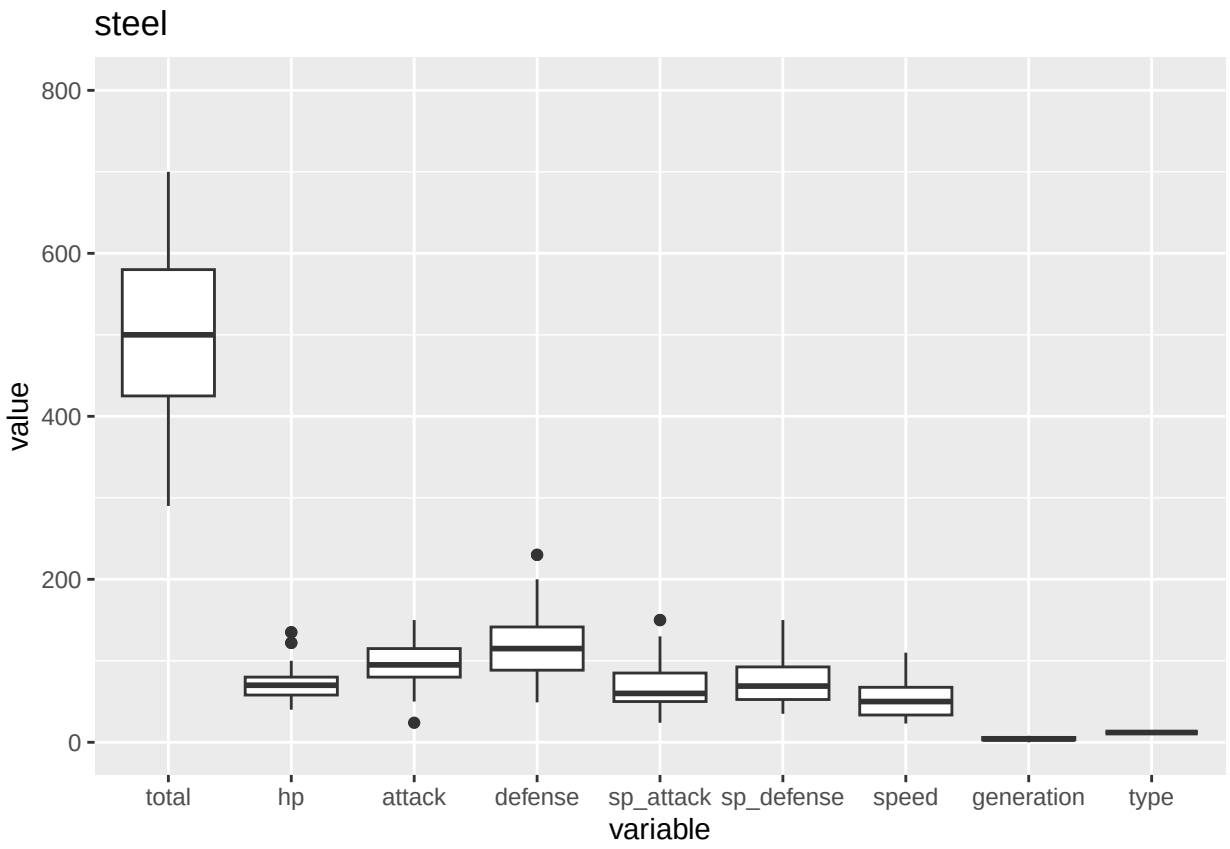

```
ggplot(ice, aes(x=variable, y=value)) +
  geom_boxplot()+coord_cartesian(ylim = c(0, 800))+ggtitle("ice")
```



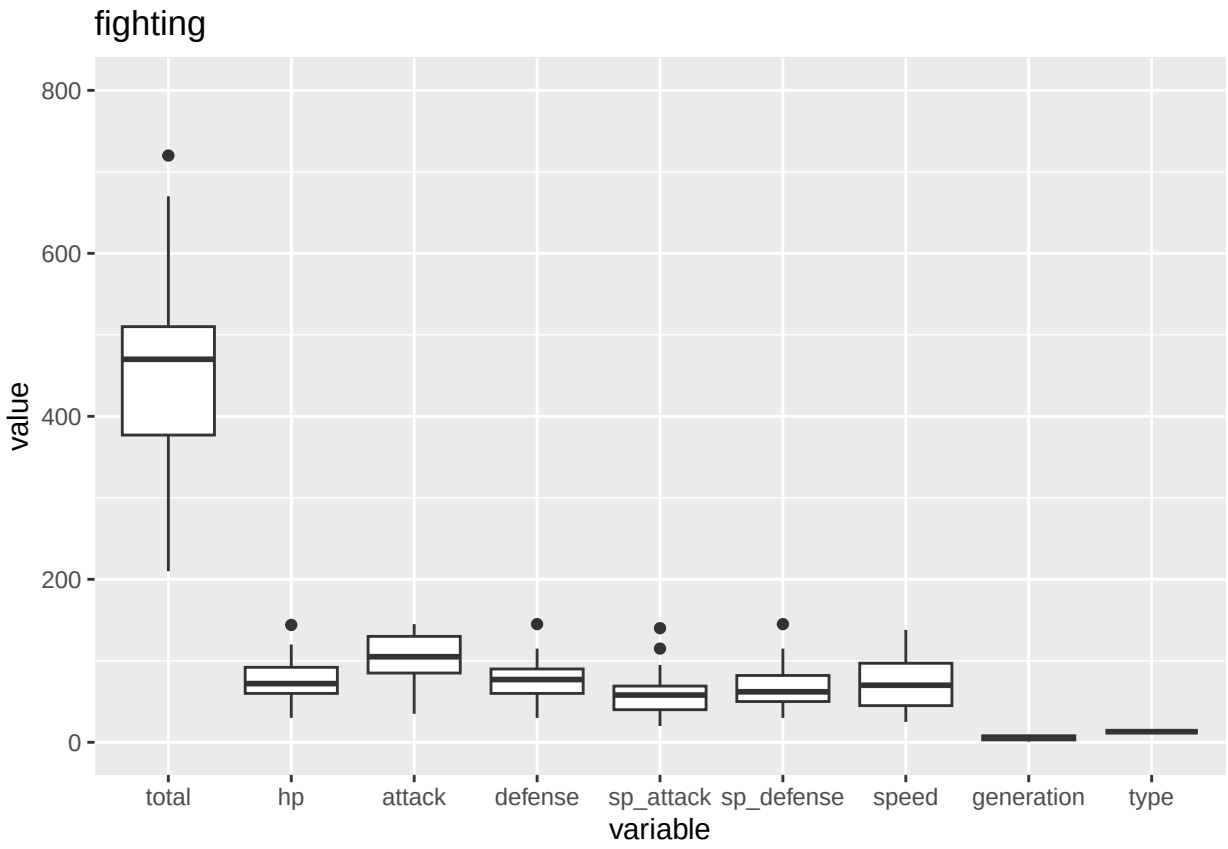

```
ggplot(fairy, aes(x=variable, y=value)) +
  geom_boxplot()+coord_cartesian(ylim = c(0, 800))+ggtitle("fairy")
```



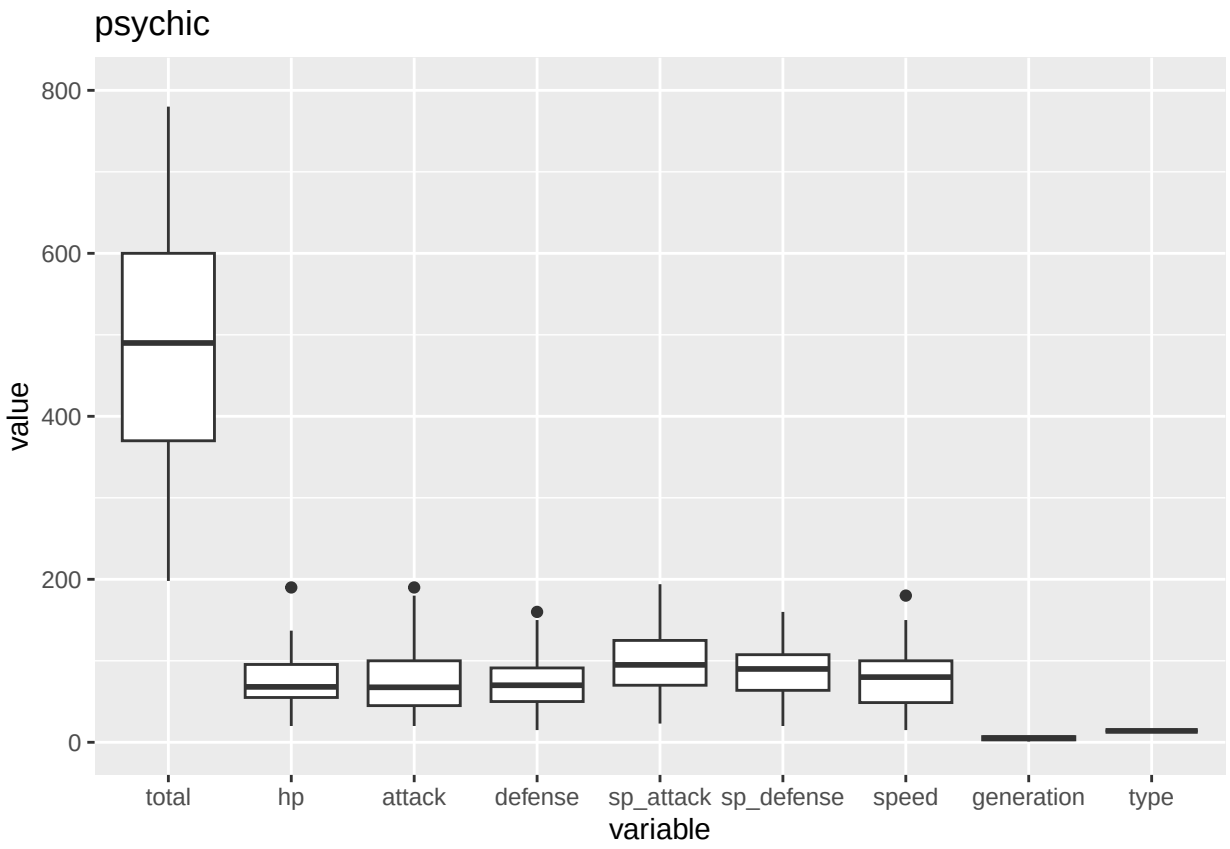

```
ggplot(steel, aes(x=variable, y=value)) +
  geom_boxplot()+coord_cartesian(ylim = c(0, 800))+ggtitle("steel")
```



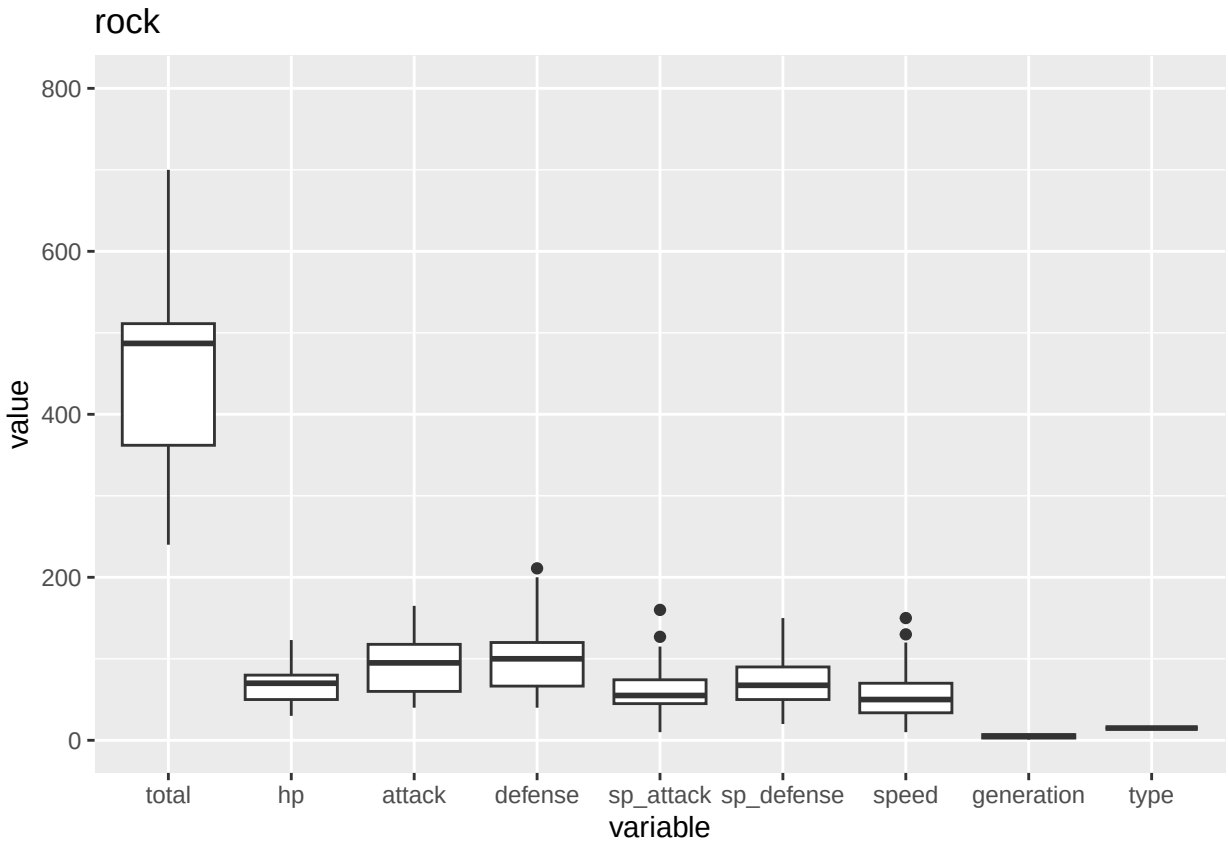

```
ggplot(fighting, aes(x=variable, y=value)) +
  geom_boxplot()+coord_cartesian(ylim = c(0, 800))+ggtitle("fighting")
```



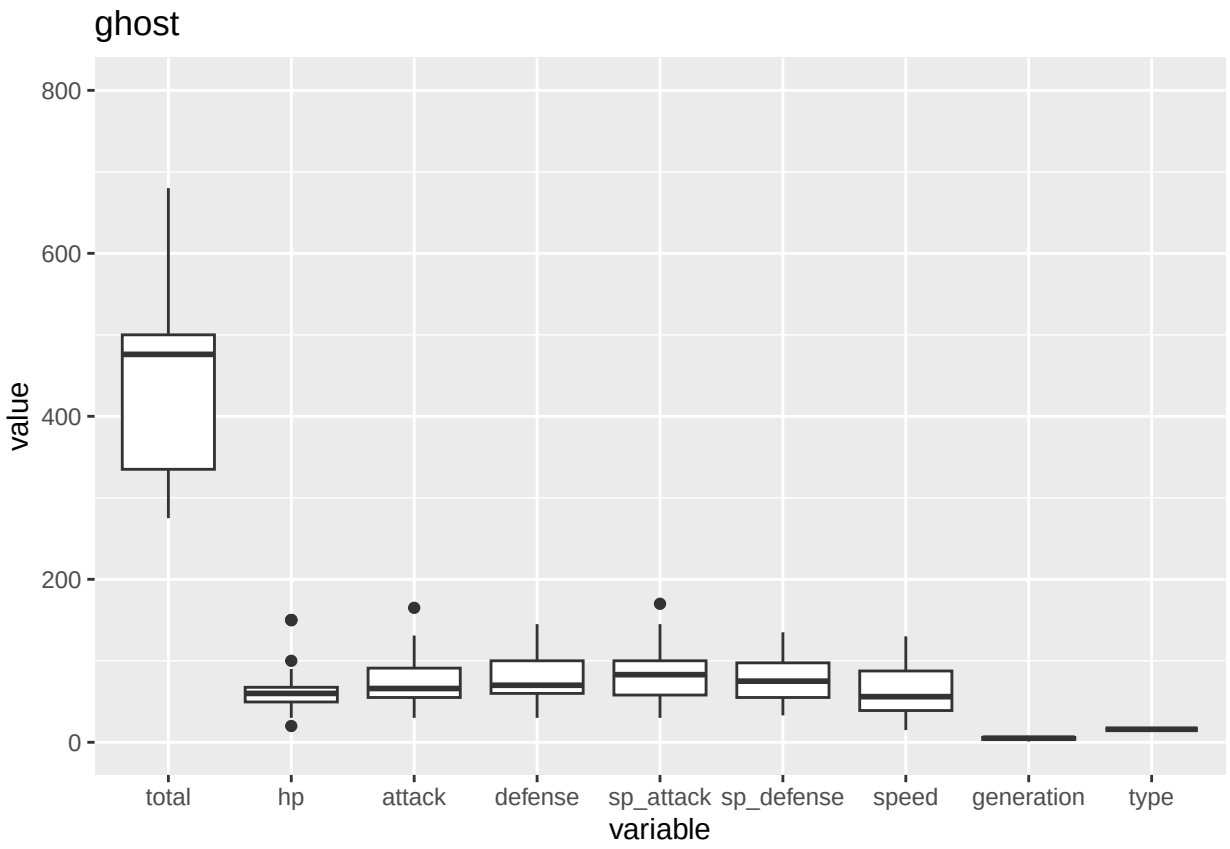

```
ggplot(psychic, aes(x=variable, y=value)) +
  geom_boxplot()+coord_cartesian(ylim = c(0, 800))+ggtitle("psychic")
```



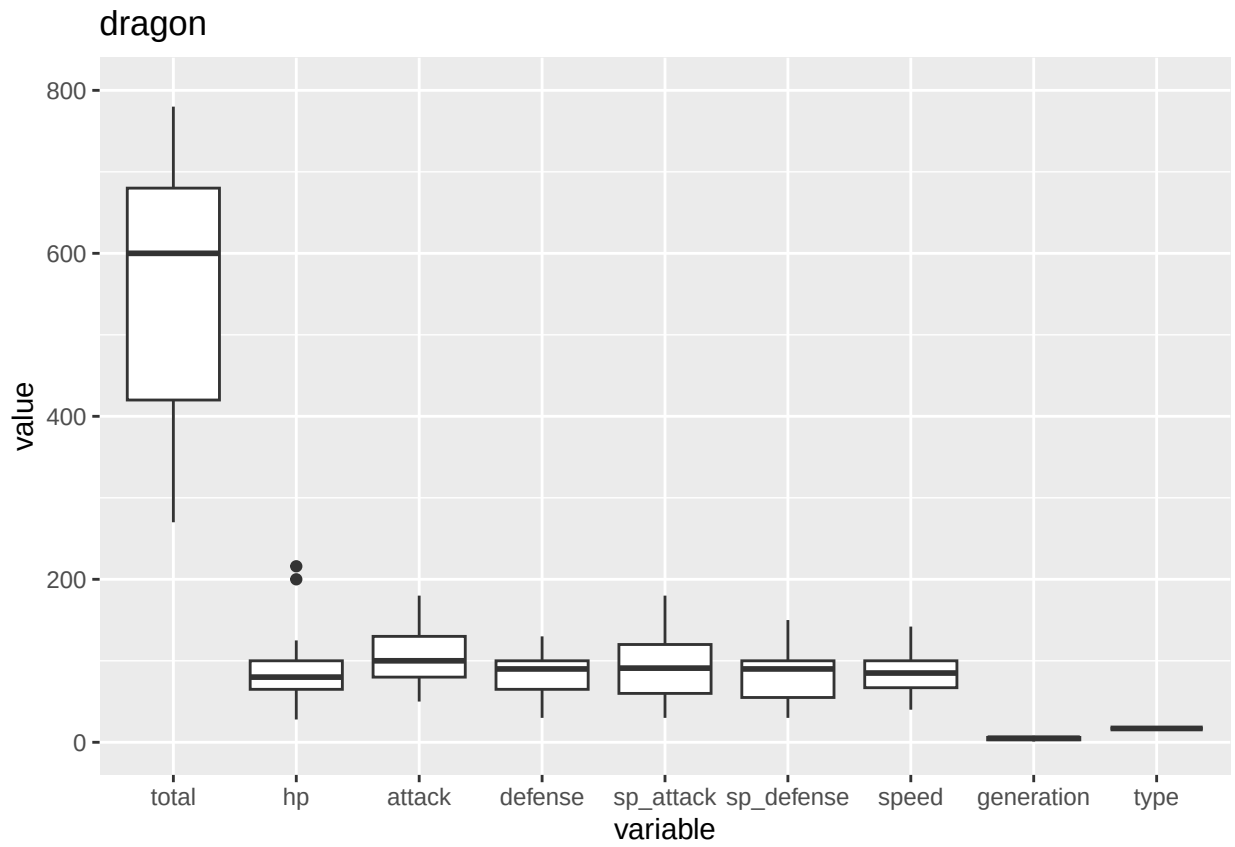

```
ggplot(rock, aes(x=variable, y=value)) +
  geom_boxplot()+coord_cartesian(ylim = c(0, 800))+ggtitle("rock")
```




```
ggplot(ghost, aes(x=variable, y=value)) +
  geom_boxplot()+coord_cartesian(ylim = c(0, 800))+ggtitle("ghost")
```

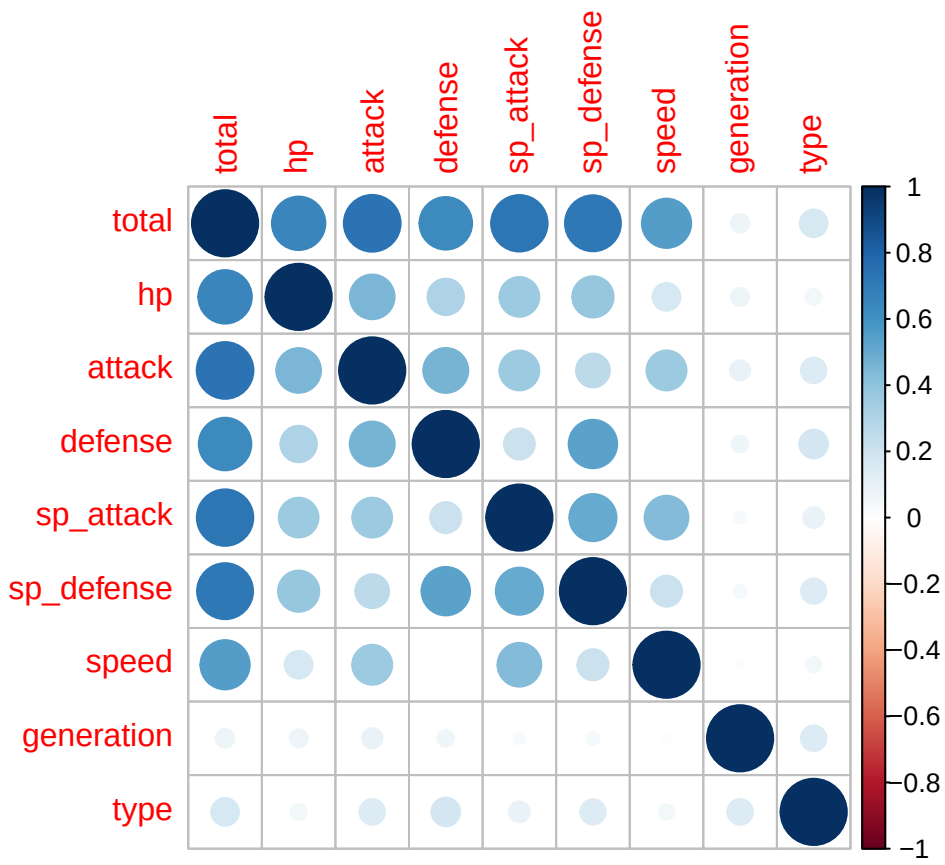



```
ggplot(dragon, aes(x=variable, y=value)) +
  geom_boxplot()+coord_cartesian(ylim = c(0, 800))+ggtitle("dragon")
```



correlation matrix

```
#pokemon_trim['type1']
#mon_ma <- as.matrix(pokemon_trim[, 1:9])
#mon_ma
pokemon_slim<-pokemon_trim %>%
    select(!type1)
corrplot(cor(pokemon_slim))
```




```
summary(pokemon_df$type)
```

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##   1.000   3.000   6.000   7.718  13.000  18.000
```

partitioning the data into train and test sets. and scaling for kNN

```
set.seed(9)
pokemon_knn<-pokemon_trim%>% select(!type1)
#head(pokemon_knn)
len<-length(pokemon_trim$type1)
#print(len)
square<-sqrt(len)
#print(square)
k<-round(square)

y = createDataPartition(pokemon_knn$type, p = .8, list = F)
train_y = pokemon_trim[y, ]
test_y = pokemon_trim[-y, ]
train_scale <- scale(train_y[, 2:9])
test_scale <- scale(test_y[, 2:9])
```

KNN pokemon model

explore multiple values for K

```r
#print(k)
for (i in 5:(k+10)){
  set.seed(9)
  classifier_knn <- knn(train = train_scale,
                        test = test_scale,
                        cl = train_y$type,
                        k=i)
  cm<-as.matrix(table(Actual = test_y$type, Predicted = classifier_knn))
  print(i)
  print(sum(diag(cm))/length(test_y$type))
  #classifier_knn
}
```

```
## [1] 5
## [1] 0.1698113
## [1] 6
## [1] 0.1886792
## [1] 7
## [1] 0.1886792
## [1] 8
## [1] 0.2075472
## [1] 9
## [1] 0.1886792
## [1] 10
## [1] 0.1792453
## [1] 11
## [1] 0.1933962
## [1] 12
## [1] 0.1933962
## [1] 13
## [1] 0.1933962
## [1] 14
## [1] 0.1603774
## [1] 15
## [1] 0.1462264
## [1] 16
## [1] 0.1933962
## [1] 17
## [1] 0.1745283
## [1] 18
## [1] 0.1603774
## [1] 19
## [1] 0.1839623
## [1] 20
## [1] 0.1650943
## [1] 21
## [1] 0.1745283
## [1] 22
## [1] 0.2028302
## [1] 23
## [1] 0.1886792
## [1] 24
## [1] 0.1792453
```

```
## [1] 25
## [1] 0.1792453
## [1] 26
## [1] 0.1745283
## [1] 27
## [1] 0.1886792
## [1] 28
## [1] 0.1933962
## [1] 29
## [1] 0.1792453
## [1] 30
## [1] 0.1886792
## [1] 31
## [1] 0.1839623
## [1] 32
## [1] 0.1745283
## [1] 33
## [1] 0.1933962
## [1] 34
## [1] 0.1933962
## [1] 35
## [1] 0.1886792
## [1] 36
## [1] 0.1933962
## [1] 37
## [1] 0.1886792
## [1] 38
## [1] 0.1886792
## [1] 39
## [1] 0.1981132
## [1] 40
## [1] 0.1886792
## [1] 41
## [1] 0.1933962
## [1] 42
## [1] 0.1839623
## [1] 43
## [1] 0.1839623
```

```
# best k value is 21
```

final KNN model

```
#relevel(test_y)
#levels(classifier_knn)
set.seed(9)
classifier_knn_final <- knn(train = train_scale,
                      test = test_scale,
                      cl = train_y$type,
                      k=8)
cm_knn<-(confusionMatrix(data = factor(classifier_knn_final), reference = factor(test_y$type)))
```

```
## Warning in levels(reference) != levels(data): longer object length is not a
## multiple of shorter object length
```

```
## Warning in confusionMatrix.default(data = factor(classifier_knn_final), : Levels
## are not in the same order for reference and data. Refactoring data to match.
```

```
cm_knn
```

```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18
##         1   2  0  3  1  2  0  0  0  0  1  1  1  0  2  0  0  0  0
##         2   2  5  4  1  0  1  1  4  0  0  0  1  2  1  1  2  0  0
##         3   3  2  5  2  5  1  2  0  2  0  1  1  1  2  4  3  3  0
##         4   3  0  1  4  2  1  1  0  0  0  0  2  4  1  0  0  0  0
##         5   1  1  4  1 12  3  2  1  1  1  2  0  1  0  0  0  0  1
##         6   0  0  2  0  2  0  0  0  0  0  0  1  0  1  0  0  0  0
##         7   0  0  1  0  2  0  0  0  0  0  1  0  0  0  0  0  0  0
##         8   2  1  2  0  1  1  0  4  0  0  0  0  0  1  0  1  1  0
##         9   0  0  0  0  0  0  0  0  2  0  0  1  0  0  1  0  0  0
##         10  0  2  1  0  0  0  0  0  0  0  1  0  0  1  0  1  0  0
##         11  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
##         12  0  0  0  1  0  0  0  0  0  0  0  0  0  0  0  0  0  0
##         13  0  0  1  0  0  0  1  0  1  0  0  0  0  1  1  0  0  0
##         14  2  2  0  1  1  1  2  0  0  3  1  0  0  4  0  2  1  0
##         15  1  1  0  0  0  0  1  0  2  2  0  0  0  1  1  0  1  0
##         16  3  1  1  1  0  0  0  0  0  0  0  2  0  0  1  2  0  0
##         17  0  0  0  0  0  1  0  0  0  0  0  0  0  1  0  0  3  0
##         18  0  0  0  1  0  0  0  0  0  0  0  0  0  0  0  0  0  0
##
## Overall Statistics
##
##                Accuracy : 0.2075
##                  95% CI : (0.155, 0.2684)
##     No Information Rate : 0.1274
##     P-Value [Acc > NIR] : 0.0007198
##
##                   Kappa : 0.1396
##
##  Mcnemar's Test P-Value : NA
##
## Statistics by Class:
##
##                      Class: 1 Class: 2 Class: 3 Class: 4 Class: 5 Class: 6
## Sensitivity          0.105263  0.33333  0.20000  0.30769   0.4444  0.00000
## Specificity          0.943005  0.89848  0.82888  0.92462   0.8973  0.97044
## Pos Pred Value       0.153846  0.20000  0.13514  0.21053   0.3871  0.00000
## Neg Pred Value       0.914573  0.94652  0.88571  0.95337   0.9171  0.95631
## Prevalence           0.089623  0.07075  0.11792  0.06132   0.1274  0.04245
## Detection Rate       0.009434  0.02358  0.02358  0.01887   0.0566  0.00000
## Detection Prevalence 0.061321  0.11792  0.17453  0.08962   0.1462  0.02830
## Balanced Accuracy    0.524134  0.61591  0.51444  0.61616   0.6709  0.48522
##                      Class: 7 Class: 8 Class: 9 Class: 10 Class: 11 Class: 12
## Sensitivity           0.00000  0.44444 0.250000   0.00000   0.00000  0.000000
## Specificity           0.98020  0.95074 0.990196   0.97073   1.00000  0.995074
## Pos Pred Value        0.00000  0.28571 0.500000   0.00000       NaN  0.000000
```

```
## Neg Pred Value         0.95192  0.97475 0.971154   0.96602   0.96698  0.957346
## Prevalence             0.04717  0.04245 0.037736   0.03302   0.03302  0.042453
## Detection Rate         0.00000  0.01887 0.009434   0.00000   0.00000  0.000000
## Detection Prevalence   0.01887  0.06604 0.018868   0.02830   0.00000  0.004717
## Balanced Accuracy      0.49010  0.69759 0.620098   0.48537   0.50000  0.497537
##                       Class: 13 Class: 14 Class: 15 Class: 16 Class: 17
## Sensitivity             0.00000   0.25000  0.111111  0.181818   0.33333
## Specificity             0.97549   0.91837  0.955665  0.955224   0.99015
## Pos Pred Value          0.00000   0.20000  0.100000  0.181818   0.60000
## Neg Pred Value          0.96135   0.93750  0.960396  0.955224   0.97101
## Prevalence              0.03774   0.07547  0.042453  0.051887   0.04245
## Detection Rate          0.00000   0.01887  0.004717  0.009434   0.01415
## Detection Prevalence    0.02358   0.09434  0.047170  0.051887   0.02358
## Balanced Accuracy       0.48775   0.58418  0.533388  0.568521   0.66174
##                       Class: 18
## Sensitivity            0.000000
## Specificity            0.995261
## Pos Pred Value         0.000000
## Neg Pred Value         0.995261
## Prevalence             0.004717
## Detection Rate         0.000000
## Detection Prevalence   0.004717
## Balanced Accuracy      0.497630
```

```
#cm <- confusionMatrix(test_y$type1, classifier_knn)
#cm$overall['Accuracy']
```

Pokemon XGboost model

```
set.seed(9)
#pokemon_trim<-pokemon_trim  %>% select(!type1)
p = createDataPartition(pokemon_trim$type, p = .8, list = F)
train_p = pokemon_trim[p, ]
#print(train_p$type)
test_p = pokemon_trim[-p, ]
#train_z[,10]
train_px = data.matrix(train_p[, -10])
train_py = train_p[,10]
#train_py
test_px = data.matrix(test_p[, -10])
test_py = test_p[, 10]
#length(train_zy)
#train_zx

xgb_train = xgb.DMatrix(data = train_px, label = train_py)
xgb_test = xgb.DMatrix(data = test_px, label = test_py)
#train_zy
#pokemon_trim$type
```

```
#define watchlist
watchlist = list(train=xgb_train, test=xgb_test)
```

```r
#fit XGBoost model and display training and testing data at each round
model = xgb.train(data = xgb_train, max.depth = 3, watchlist=watchlist, nrounds = 475)
```

```
## [1]  train-rmse:6.758974 test-rmse:6.853613
## [2]  train-rmse:5.440787 test-rmse:5.553056
## [3]  train-rmse:4.620149 test-rmse:4.752661
## [4]  train-rmse:3.938504 test-rmse:4.052786
## [5]  train-rmse:3.577398 test-rmse:3.711579
## [6]  train-rmse:3.224225 test-rmse:3.396426
## [7]  train-rmse:3.056500 test-rmse:3.227985
## [8]  train-rmse:2.855696 test-rmse:3.010811
## [9]  train-rmse:2.534213 test-rmse:2.738593
## [10] train-rmse:2.456933 test-rmse:2.656492
## [11] train-rmse:2.340877 test-rmse:2.528581
## [12] train-rmse:2.004473 test-rmse:2.133750
## [13] train-rmse:1.935417 test-rmse:2.063307
## [14] train-rmse:1.648100 test-rmse:1.745538
## [15] train-rmse:1.390015 test-rmse:1.465994
## [16] train-rmse:1.283823 test-rmse:1.361021
## [17] train-rmse:1.157442 test-rmse:1.234000
## [18] train-rmse:1.116623 test-rmse:1.194408
## [19] train-rmse:1.066408 test-rmse:1.142402
## [20] train-rmse:1.039320 test-rmse:1.121009
## [21] train-rmse:1.010260 test-rmse:1.091761
## [22] train-rmse:0.883061 test-rmse:0.944370
## [23] train-rmse:0.756621 test-rmse:0.801796
## [24] train-rmse:0.711449 test-rmse:0.755968
## [25] train-rmse:0.657459 test-rmse:0.699019
## [26] train-rmse:0.638476 test-rmse:0.687332
## [27] train-rmse:0.619626 test-rmse:0.666376
## [28] train-rmse:0.569308 test-rmse:0.601492
## [29] train-rmse:0.529097 test-rmse:0.567894
## [30] train-rmse:0.490770 test-rmse:0.540862
## [31] train-rmse:0.471352 test-rmse:0.519934
## [32] train-rmse:0.423012 test-rmse:0.457830
## [33] train-rmse:0.401535 test-rmse:0.428565
## [34] train-rmse:0.378825 test-rmse:0.411972
## [35] train-rmse:0.334358 test-rmse:0.349304
## [36] train-rmse:0.322518 test-rmse:0.340604
## [37] train-rmse:0.313579 test-rmse:0.330831
## [38] train-rmse:0.294268 test-rmse:0.318691
## [39] train-rmse:0.261282 test-rmse:0.276698
## [40] train-rmse:0.247836 test-rmse:0.265718
## [41] train-rmse:0.241374 test-rmse:0.257294
## [42] train-rmse:0.228344 test-rmse:0.249614
## [43] train-rmse:0.208681 test-rmse:0.225413
## [44] train-rmse:0.197046 test-rmse:0.209874
## [45] train-rmse:0.188705 test-rmse:0.203185
## [46] train-rmse:0.176799 test-rmse:0.191882
## [47] train-rmse:0.171540 test-rmse:0.185165
## [48] train-rmse:0.166316 test-rmse:0.182583
## [49] train-rmse:0.161150 test-rmse:0.178165
## [50] train-rmse:0.146162 test-rmse:0.161256
```

```
## [51] train-rmse:0.142674 test-rmse:0.156774
## [52] train-rmse:0.136211 test-rmse:0.150697
## [53] train-rmse:0.132948 test-rmse:0.148855
## [54] train-rmse:0.128439 test-rmse:0.146264
## [55] train-rmse:0.124722 test-rmse:0.145786
## [56] train-rmse:0.120519 test-rmse:0.141152
## [57] train-rmse:0.117056 test-rmse:0.138424
## [58] train-rmse:0.114107 test-rmse:0.137296
## [59] train-rmse:0.113148 test-rmse:0.137037
## [60] train-rmse:0.108020 test-rmse:0.135673
## [61] train-rmse:0.105786 test-rmse:0.135323
## [62] train-rmse:0.102434 test-rmse:0.133403
## [63] train-rmse:0.100100 test-rmse:0.131560
## [64] train-rmse:0.096077 test-rmse:0.129412
## [65] train-rmse:0.094543 test-rmse:0.130053
## [66] train-rmse:0.094205 test-rmse:0.130125
## [67] train-rmse:0.092755 test-rmse:0.128911
## [68] train-rmse:0.091632 test-rmse:0.129039
## [69] train-rmse:0.089614 test-rmse:0.128383
## [70] train-rmse:0.086373 test-rmse:0.126368
## [71] train-rmse:0.083499 test-rmse:0.122896
## [72] train-rmse:0.082778 test-rmse:0.122633
## [73] train-rmse:0.082572 test-rmse:0.122659
## [74] train-rmse:0.081795 test-rmse:0.121568
## [75] train-rmse:0.080770 test-rmse:0.121662
## [76] train-rmse:0.079858 test-rmse:0.122163
## [77] train-rmse:0.079414 test-rmse:0.122104
## [78] train-rmse:0.078046 test-rmse:0.122148
## [79] train-rmse:0.077694 test-rmse:0.122484
## [80] train-rmse:0.076871 test-rmse:0.122015
## [81] train-rmse:0.075061 test-rmse:0.120570
## [82] train-rmse:0.073267 test-rmse:0.119753
## [83] train-rmse:0.072088 test-rmse:0.119027
## [84] train-rmse:0.068567 test-rmse:0.113900
## [85] train-rmse:0.067651 test-rmse:0.113533
## [86] train-rmse:0.065932 test-rmse:0.113117
## [87] train-rmse:0.065385 test-rmse:0.113234
## [88] train-rmse:0.065115 test-rmse:0.113322
## [89] train-rmse:0.064782 test-rmse:0.113450
## [90] train-rmse:0.064084 test-rmse:0.113174
## [91] train-rmse:0.063631 test-rmse:0.113052
## [92] train-rmse:0.061779 test-rmse:0.112436
## [93] train-rmse:0.060947 test-rmse:0.112106
## [94] train-rmse:0.060417 test-rmse:0.111772
## [95] train-rmse:0.059288 test-rmse:0.111095
## [96] train-rmse:0.058845 test-rmse:0.110676
## [97] train-rmse:0.058770 test-rmse:0.110709
## [98] train-rmse:0.058451 test-rmse:0.110646
## [99] train-rmse:0.058292 test-rmse:0.110597
## [100]    train-rmse:0.057785 test-rmse:0.111025
## [101]    train-rmse:0.057452 test-rmse:0.110957
## [102]    train-rmse:0.057212 test-rmse:0.110997
## [103]    train-rmse:0.056917 test-rmse:0.110867
## [104]    train-rmse:0.056545 test-rmse:0.110745
```

```
## [105]    train-rmse:0.056244 test-rmse:0.110565
## [106]    train-rmse:0.055823 test-rmse:0.110671
## [107]    train-rmse:0.055724 test-rmse:0.110719
## [108]    train-rmse:0.053457 test-rmse:0.109319
## [109]    train-rmse:0.052882 test-rmse:0.110170
## [110]    train-rmse:0.052549 test-rmse:0.110252
## [111]    train-rmse:0.051819 test-rmse:0.109961
## [112]    train-rmse:0.051263 test-rmse:0.109908
## [113]    train-rmse:0.051112 test-rmse:0.110101
## [114]    train-rmse:0.050876 test-rmse:0.110153
## [115]    train-rmse:0.050343 test-rmse:0.110246
## [116]    train-rmse:0.050107 test-rmse:0.110108
## [117]    train-rmse:0.049634 test-rmse:0.110109
## [118]    train-rmse:0.049213 test-rmse:0.110359
## [119]    train-rmse:0.048790 test-rmse:0.110255
## [120]    train-rmse:0.048646 test-rmse:0.110173
## [121]    train-rmse:0.048436 test-rmse:0.110074
## [122]    train-rmse:0.047772 test-rmse:0.110024
## [123]    train-rmse:0.047473 test-rmse:0.110127
## [124]    train-rmse:0.047075 test-rmse:0.109941
## [125]    train-rmse:0.047017 test-rmse:0.109893
## [126]    train-rmse:0.046850 test-rmse:0.109910
## [127]    train-rmse:0.046576 test-rmse:0.109385
## [128]    train-rmse:0.045602 test-rmse:0.109424
## [129]    train-rmse:0.045535 test-rmse:0.109452
## [130]    train-rmse:0.045502 test-rmse:0.109481
## [131]    train-rmse:0.045327 test-rmse:0.109415
## [132]    train-rmse:0.045061 test-rmse:0.109346
## [133]    train-rmse:0.044851 test-rmse:0.109439
## [134]    train-rmse:0.044687 test-rmse:0.109517
## [135]    train-rmse:0.042892 test-rmse:0.106997
## [136]    train-rmse:0.042475 test-rmse:0.107020
## [137]    train-rmse:0.042115 test-rmse:0.106906
## [138]    train-rmse:0.041837 test-rmse:0.107138
## [139]    train-rmse:0.041378 test-rmse:0.106968
## [140]    train-rmse:0.041196 test-rmse:0.106964
## [141]    train-rmse:0.040749 test-rmse:0.107174
## [142]    train-rmse:0.040404 test-rmse:0.107364
## [143]    train-rmse:0.040145 test-rmse:0.107299
## [144]    train-rmse:0.039907 test-rmse:0.107356
## [145]    train-rmse:0.039864 test-rmse:0.107493
## [146]    train-rmse:0.039515 test-rmse:0.107102
## [147]    train-rmse:0.039187 test-rmse:0.107109
## [148]    train-rmse:0.038965 test-rmse:0.107068
## [149]    train-rmse:0.038892 test-rmse:0.107106
## [150]    train-rmse:0.038635 test-rmse:0.107014
## [151]    train-rmse:0.038316 test-rmse:0.106883
## [152]    train-rmse:0.037962 test-rmse:0.106911
## [153]    train-rmse:0.037690 test-rmse:0.106697
## [154]    train-rmse:0.037557 test-rmse:0.106686
## [155]    train-rmse:0.037522 test-rmse:0.106675
## [156]    train-rmse:0.037479 test-rmse:0.106683
## [157]    train-rmse:0.037238 test-rmse:0.106770
## [158]    train-rmse:0.037174 test-rmse:0.106716
```

```
## [159]    train-rmse:0.036890 test-rmse:0.106896
## [160]    train-rmse:0.036810 test-rmse:0.106923
## [161]    train-rmse:0.036777 test-rmse:0.106936
## [162]    train-rmse:0.036562 test-rmse:0.106944
## [163]    train-rmse:0.036476 test-rmse:0.106995
## [164]    train-rmse:0.036272 test-rmse:0.106989
## [165]    train-rmse:0.036049 test-rmse:0.106810
## [166]    train-rmse:0.035444 test-rmse:0.106970
## [167]    train-rmse:0.035117 test-rmse:0.106883
## [168]    train-rmse:0.034903 test-rmse:0.106885
## [169]    train-rmse:0.034573 test-rmse:0.106977
## [170]    train-rmse:0.034526 test-rmse:0.106991
## [171]    train-rmse:0.034512 test-rmse:0.106991
## [172]    train-rmse:0.034361 test-rmse:0.107090
## [173]    train-rmse:0.034140 test-rmse:0.107035
## [174]    train-rmse:0.033904 test-rmse:0.107140
## [175]    train-rmse:0.033835 test-rmse:0.107230
## [176]    train-rmse:0.033709 test-rmse:0.107258
## [177]    train-rmse:0.033670 test-rmse:0.107295
## [178]    train-rmse:0.033609 test-rmse:0.107248
## [179]    train-rmse:0.033132 test-rmse:0.106826
## [180]    train-rmse:0.032972 test-rmse:0.106803
## [181]    train-rmse:0.032872 test-rmse:0.106847
## [182]    train-rmse:0.032508 test-rmse:0.106695
## [183]    train-rmse:0.032340 test-rmse:0.106772
## [184]    train-rmse:0.032191 test-rmse:0.106816
## [185]    train-rmse:0.031969 test-rmse:0.106761
## [186]    train-rmse:0.031774 test-rmse:0.106820
## [187]    train-rmse:0.031557 test-rmse:0.106693
## [188]    train-rmse:0.031334 test-rmse:0.106629
## [189]    train-rmse:0.031299 test-rmse:0.106660
## [190]    train-rmse:0.030506 test-rmse:0.105212
## [191]    train-rmse:0.030479 test-rmse:0.105130
## [192]    train-rmse:0.030251 test-rmse:0.105345
## [193]    train-rmse:0.030035 test-rmse:0.105328
## [194]    train-rmse:0.029865 test-rmse:0.105318
## [195]    train-rmse:0.029689 test-rmse:0.105227
## [196]    train-rmse:0.029532 test-rmse:0.105262
## [197]    train-rmse:0.029351 test-rmse:0.105156
## [198]    train-rmse:0.029229 test-rmse:0.104816
## [199]    train-rmse:0.029216 test-rmse:0.104828
## [200]    train-rmse:0.029045 test-rmse:0.104770
## [201]    train-rmse:0.028853 test-rmse:0.104671
## [202]    train-rmse:0.028734 test-rmse:0.104706
## [203]    train-rmse:0.028687 test-rmse:0.104729
## [204]    train-rmse:0.028658 test-rmse:0.104701
## [205]    train-rmse:0.028643 test-rmse:0.104718
## [206]    train-rmse:0.028558 test-rmse:0.104774
## [207]    train-rmse:0.028339 test-rmse:0.104733
## [208]    train-rmse:0.028311 test-rmse:0.104747
## [209]    train-rmse:0.028243 test-rmse:0.104913
## [210]    train-rmse:0.028111 test-rmse:0.104950
## [211]    train-rmse:0.027970 test-rmse:0.104964
## [212]    train-rmse:0.027947 test-rmse:0.104976
```

```
## [213]    train-rmse:0.027836 test-rmse:0.104949
## [214]    train-rmse:0.027692 test-rmse:0.105016
## [215]    train-rmse:0.027572 test-rmse:0.105103
## [216]    train-rmse:0.027398 test-rmse:0.105081
## [217]    train-rmse:0.027276 test-rmse:0.105105
## [218]    train-rmse:0.027032 test-rmse:0.104992
## [219]    train-rmse:0.026955 test-rmse:0.105054
## [220]    train-rmse:0.026837 test-rmse:0.105238
## [221]    train-rmse:0.026810 test-rmse:0.105252
## [222]    train-rmse:0.026801 test-rmse:0.105241
## [223]    train-rmse:0.026632 test-rmse:0.105226
## [224]    train-rmse:0.026482 test-rmse:0.105205
## [225]    train-rmse:0.026415 test-rmse:0.105131
## [226]    train-rmse:0.026276 test-rmse:0.104987
## [227]    train-rmse:0.026210 test-rmse:0.105056
## [228]    train-rmse:0.026170 test-rmse:0.105049
## [229]    train-rmse:0.026076 test-rmse:0.105066
## [230]    train-rmse:0.025958 test-rmse:0.105190
## [231]    train-rmse:0.025880 test-rmse:0.105199
## [232]    train-rmse:0.025815 test-rmse:0.105170
## [233]    train-rmse:0.025680 test-rmse:0.105066
## [234]    train-rmse:0.025646 test-rmse:0.105049
## [235]    train-rmse:0.025422 test-rmse:0.104800
## [236]    train-rmse:0.025352 test-rmse:0.104678
## [237]    train-rmse:0.025144 test-rmse:0.104642
## [238]    train-rmse:0.025112 test-rmse:0.104651
## [239]    train-rmse:0.025060 test-rmse:0.104692
## [240]    train-rmse:0.024966 test-rmse:0.104720
## [241]    train-rmse:0.024914 test-rmse:0.104727
## [242]    train-rmse:0.024710 test-rmse:0.104716
## [243]    train-rmse:0.024576 test-rmse:0.104783
## [244]    train-rmse:0.024441 test-rmse:0.104669
## [245]    train-rmse:0.024399 test-rmse:0.104696
## [246]    train-rmse:0.024380 test-rmse:0.104678
## [247]    train-rmse:0.024298 test-rmse:0.104706
## [248]    train-rmse:0.024195 test-rmse:0.104878
## [249]    train-rmse:0.024030 test-rmse:0.104950
## [250]    train-rmse:0.024014 test-rmse:0.104951
## [251]    train-rmse:0.023877 test-rmse:0.105015
## [252]    train-rmse:0.023810 test-rmse:0.105050
## [253]    train-rmse:0.023735 test-rmse:0.105063
## [254]    train-rmse:0.023603 test-rmse:0.105071
## [255]    train-rmse:0.023563 test-rmse:0.105002
## [256]    train-rmse:0.023486 test-rmse:0.105007
## [257]    train-rmse:0.023470 test-rmse:0.105012
## [258]    train-rmse:0.023356 test-rmse:0.105025
## [259]    train-rmse:0.023259 test-rmse:0.105024
## [260]    train-rmse:0.023118 test-rmse:0.104802
## [261]    train-rmse:0.023053 test-rmse:0.104833
## [262]    train-rmse:0.022898 test-rmse:0.104703
## [263]    train-rmse:0.022739 test-rmse:0.104638
## [264]    train-rmse:0.022597 test-rmse:0.104537
## [265]    train-rmse:0.022514 test-rmse:0.104577
## [266]    train-rmse:0.022485 test-rmse:0.104596
```

```
## [267]    train-rmse:0.022334 test-rmse:0.104613
## [268]    train-rmse:0.022261 test-rmse:0.104739
## [269]    train-rmse:0.022248 test-rmse:0.104751
## [270]    train-rmse:0.022225 test-rmse:0.104645
## [271]    train-rmse:0.022104 test-rmse:0.104594
## [272]    train-rmse:0.021997 test-rmse:0.104647
## [273]    train-rmse:0.021828 test-rmse:0.104726
## [274]    train-rmse:0.021717 test-rmse:0.104740
## [275]    train-rmse:0.021598 test-rmse:0.104759
## [276]    train-rmse:0.021472 test-rmse:0.104824
## [277]    train-rmse:0.021074 test-rmse:0.104417
## [278]    train-rmse:0.021019 test-rmse:0.104446
## [279]    train-rmse:0.021009 test-rmse:0.104402
## [280]    train-rmse:0.020897 test-rmse:0.104541
## [281]    train-rmse:0.020823 test-rmse:0.104565
## [282]    train-rmse:0.020704 test-rmse:0.104513
## [283]    train-rmse:0.020699 test-rmse:0.104519
## [284]    train-rmse:0.020678 test-rmse:0.104548
## [285]    train-rmse:0.020470 test-rmse:0.104435
## [286]    train-rmse:0.020421 test-rmse:0.104520
## [287]    train-rmse:0.020304 test-rmse:0.104469
## [288]    train-rmse:0.020238 test-rmse:0.104546
## [289]    train-rmse:0.020207 test-rmse:0.104506
## [290]    train-rmse:0.020173 test-rmse:0.104421
## [291]    train-rmse:0.020110 test-rmse:0.104398
## [292]    train-rmse:0.020086 test-rmse:0.104428
## [293]    train-rmse:0.020076 test-rmse:0.104439
## [294]    train-rmse:0.020007 test-rmse:0.104455
## [295]    train-rmse:0.019865 test-rmse:0.104453
## [296]    train-rmse:0.019842 test-rmse:0.104457
## [297]    train-rmse:0.019763 test-rmse:0.104493
## [298]    train-rmse:0.019605 test-rmse:0.104506
## [299]    train-rmse:0.019465 test-rmse:0.104487
## [300]    train-rmse:0.019341 test-rmse:0.104469
## [301]    train-rmse:0.019274 test-rmse:0.104494
## [302]    train-rmse:0.019187 test-rmse:0.104446
## [303]    train-rmse:0.019136 test-rmse:0.104447
## [304]    train-rmse:0.018992 test-rmse:0.104314
## [305]    train-rmse:0.018858 test-rmse:0.104285
## [306]    train-rmse:0.018818 test-rmse:0.104249
## [307]    train-rmse:0.018719 test-rmse:0.104145
## [308]    train-rmse:0.018631 test-rmse:0.104176
## [309]    train-rmse:0.018517 test-rmse:0.104131
## [310]    train-rmse:0.018500 test-rmse:0.104106
## [311]    train-rmse:0.018475 test-rmse:0.104106
## [312]    train-rmse:0.018445 test-rmse:0.104138
## [313]    train-rmse:0.018341 test-rmse:0.104170
## [314]    train-rmse:0.018257 test-rmse:0.104185
## [315]    train-rmse:0.018192 test-rmse:0.104132
## [316]    train-rmse:0.018086 test-rmse:0.104126
## [317]    train-rmse:0.018029 test-rmse:0.104065
## [318]    train-rmse:0.017993 test-rmse:0.104068
## [319]    train-rmse:0.017911 test-rmse:0.104050
## [320]    train-rmse:0.017858 test-rmse:0.104222
```

```
## [321]    train-rmse:0.017837 test-rmse:0.104224
## [322]    train-rmse:0.017772 test-rmse:0.104235
## [323]    train-rmse:0.017717 test-rmse:0.104290
## [324]    train-rmse:0.017704 test-rmse:0.104287
## [325]    train-rmse:0.017618 test-rmse:0.104285
## [326]    train-rmse:0.017587 test-rmse:0.104443
## [327]    train-rmse:0.017519 test-rmse:0.104491
## [328]    train-rmse:0.017469 test-rmse:0.104443
## [329]    train-rmse:0.017416 test-rmse:0.104469
## [330]    train-rmse:0.017390 test-rmse:0.104473
## [331]    train-rmse:0.017342 test-rmse:0.104410
## [332]    train-rmse:0.017299 test-rmse:0.104451
## [333]    train-rmse:0.017193 test-rmse:0.104420
## [334]    train-rmse:0.017161 test-rmse:0.104412
## [335]    train-rmse:0.017070 test-rmse:0.104415
## [336]    train-rmse:0.016936 test-rmse:0.104443
## [337]    train-rmse:0.016891 test-rmse:0.104419
## [338]    train-rmse:0.016841 test-rmse:0.104466
## [339]    train-rmse:0.016826 test-rmse:0.104478
## [340]    train-rmse:0.016759 test-rmse:0.104472
## [341]    train-rmse:0.016683 test-rmse:0.104478
## [342]    train-rmse:0.016597 test-rmse:0.104417
## [343]    train-rmse:0.016534 test-rmse:0.104500
## [344]    train-rmse:0.016370 test-rmse:0.104277
## [345]    train-rmse:0.016282 test-rmse:0.104209
## [346]    train-rmse:0.016245 test-rmse:0.104196
## [347]    train-rmse:0.016173 test-rmse:0.104249
## [348]    train-rmse:0.016135 test-rmse:0.104255
## [349]    train-rmse:0.016116 test-rmse:0.104238
## [350]    train-rmse:0.016100 test-rmse:0.104239
## [351]    train-rmse:0.016082 test-rmse:0.104223
## [352]    train-rmse:0.016061 test-rmse:0.104186
## [353]    train-rmse:0.016018 test-rmse:0.104183
## [354]    train-rmse:0.016011 test-rmse:0.104178
## [355]    train-rmse:0.015929 test-rmse:0.104232
## [356]    train-rmse:0.015854 test-rmse:0.104280
## [357]    train-rmse:0.015827 test-rmse:0.104321
## [358]    train-rmse:0.015753 test-rmse:0.104343
## [359]    train-rmse:0.015739 test-rmse:0.104309
## [360]    train-rmse:0.015666 test-rmse:0.104308
## [361]    train-rmse:0.015432 test-rmse:0.104076
## [362]    train-rmse:0.015364 test-rmse:0.104070
## [363]    train-rmse:0.015267 test-rmse:0.104062
## [364]    train-rmse:0.015201 test-rmse:0.104063
## [365]    train-rmse:0.015186 test-rmse:0.104054
## [366]    train-rmse:0.015159 test-rmse:0.104064
## [367]    train-rmse:0.015102 test-rmse:0.104104
## [368]    train-rmse:0.015091 test-rmse:0.104107
## [369]    train-rmse:0.015023 test-rmse:0.104130
## [370]    train-rmse:0.014962 test-rmse:0.104058
## [371]    train-rmse:0.014955 test-rmse:0.104054
## [372]    train-rmse:0.014932 test-rmse:0.104049
## [373]    train-rmse:0.014859 test-rmse:0.104063
## [374]    train-rmse:0.014790 test-rmse:0.104053
```

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## [375]    train-rmse:0.014659 test-rmse:0.104001
## [376]    train-rmse:0.014597 test-rmse:0.103866
## [377]    train-rmse:0.014529 test-rmse:0.103830
## [378]    train-rmse:0.014516 test-rmse:0.103842
## [379]    train-rmse:0.014467 test-rmse:0.103854
## [380]    train-rmse:0.014411 test-rmse:0.103881
## [381]    train-rmse:0.014353 test-rmse:0.103901
## [382]    train-rmse:0.014276 test-rmse:0.103856
## [383]    train-rmse:0.014233 test-rmse:0.103829
## [384]    train-rmse:0.014194 test-rmse:0.103789
## [385]    train-rmse:0.014184 test-rmse:0.103798
## [386]    train-rmse:0.014141 test-rmse:0.103793
## [387]    train-rmse:0.014092 test-rmse:0.103807
## [388]    train-rmse:0.014055 test-rmse:0.103780
## [389]    train-rmse:0.014008 test-rmse:0.103736
## [390]    train-rmse:0.013870 test-rmse:0.103739
## [391]    train-rmse:0.013854 test-rmse:0.103706
## [392]    train-rmse:0.013817 test-rmse:0.103701
## [393]    train-rmse:0.013768 test-rmse:0.103726
## [394]    train-rmse:0.013628 test-rmse:0.103585
## [395]    train-rmse:0.013587 test-rmse:0.103562
## [396]    train-rmse:0.013545 test-rmse:0.103561
## [397]    train-rmse:0.013483 test-rmse:0.103530
## [398]    train-rmse:0.013418 test-rmse:0.103508
## [399]    train-rmse:0.013405 test-rmse:0.103515
## [400]    train-rmse:0.013397 test-rmse:0.103516
## [401]    train-rmse:0.013371 test-rmse:0.103481
## [402]    train-rmse:0.013330 test-rmse:0.103479
## [403]    train-rmse:0.013294 test-rmse:0.103485
## [404]    train-rmse:0.013208 test-rmse:0.103472
## [405]    train-rmse:0.013164 test-rmse:0.103467
## [406]    train-rmse:0.013155 test-rmse:0.103466
## [407]    train-rmse:0.013102 test-rmse:0.103457
## [408]    train-rmse:0.013042 test-rmse:0.103394
## [409]    train-rmse:0.013005 test-rmse:0.103414
## [410]    train-rmse:0.012994 test-rmse:0.103398
## [411]    train-rmse:0.012988 test-rmse:0.103400
## [412]    train-rmse:0.012953 test-rmse:0.103429
## [413]    train-rmse:0.012928 test-rmse:0.103470
## [414]    train-rmse:0.012883 test-rmse:0.103473
## [415]    train-rmse:0.012829 test-rmse:0.103461
## [416]    train-rmse:0.012757 test-rmse:0.103386
## [417]    train-rmse:0.012726 test-rmse:0.103379
## [418]    train-rmse:0.012677 test-rmse:0.103404
## [419]    train-rmse:0.012665 test-rmse:0.103412
## [420]    train-rmse:0.012642 test-rmse:0.103432
## [421]    train-rmse:0.012634 test-rmse:0.103439
## [422]    train-rmse:0.012629 test-rmse:0.103435
## [423]    train-rmse:0.012621 test-rmse:0.103444
## [424]    train-rmse:0.012564 test-rmse:0.103369
## [425]    train-rmse:0.012525 test-rmse:0.103407
## [426]    train-rmse:0.012474 test-rmse:0.103381
## [427]    train-rmse:0.012414 test-rmse:0.103386
## [428]    train-rmse:0.012387 test-rmse:0.103383
```

```
## [429]    train-rmse:0.012346 test-rmse:0.103399
## [430]    train-rmse:0.012247 test-rmse:0.103254
## [431]    train-rmse:0.012194 test-rmse:0.103250
## [432]    train-rmse:0.012148 test-rmse:0.103256
## [433]    train-rmse:0.012028 test-rmse:0.103207
## [434]    train-rmse:0.011970 test-rmse:0.103222
## [435]    train-rmse:0.011923 test-rmse:0.103216
## [436]    train-rmse:0.011878 test-rmse:0.103206
## [437]    train-rmse:0.011849 test-rmse:0.103215
## [438]    train-rmse:0.011823 test-rmse:0.103239
## [439]    train-rmse:0.011802 test-rmse:0.103206
## [440]    train-rmse:0.011797 test-rmse:0.103215
## [441]    train-rmse:0.011788 test-rmse:0.103230
## [442]    train-rmse:0.011679 test-rmse:0.103195
## [443]    train-rmse:0.011652 test-rmse:0.103211
## [444]    train-rmse:0.011559 test-rmse:0.103209
## [445]    train-rmse:0.011519 test-rmse:0.103197
## [446]    train-rmse:0.011464 test-rmse:0.103211
## [447]    train-rmse:0.011457 test-rmse:0.103211
## [448]    train-rmse:0.011430 test-rmse:0.103185
## [449]    train-rmse:0.011419 test-rmse:0.103197
## [450]    train-rmse:0.011394 test-rmse:0.103246
## [451]    train-rmse:0.011371 test-rmse:0.103205
## [452]    train-rmse:0.011258 test-rmse:0.102971
## [453]    train-rmse:0.011204 test-rmse:0.102962
## [454]    train-rmse:0.011144 test-rmse:0.102897
## [455]    train-rmse:0.011102 test-rmse:0.102853
## [456]    train-rmse:0.011052 test-rmse:0.102835
## [457]    train-rmse:0.011024 test-rmse:0.102772
## [458]    train-rmse:0.010989 test-rmse:0.102736
## [459]    train-rmse:0.010963 test-rmse:0.102721
## [460]    train-rmse:0.010927 test-rmse:0.102751
## [461]    train-rmse:0.010921 test-rmse:0.102751
## [462]    train-rmse:0.010880 test-rmse:0.102658
## [463]    train-rmse:0.010856 test-rmse:0.102661
## [464]    train-rmse:0.010842 test-rmse:0.102647
## [465]    train-rmse:0.010820 test-rmse:0.102672
## [466]    train-rmse:0.010787 test-rmse:0.102684
## [467]    train-rmse:0.010750 test-rmse:0.102702
## [468]    train-rmse:0.010739 test-rmse:0.102699
## [469]    train-rmse:0.010696 test-rmse:0.102724
## [470]    train-rmse:0.010678 test-rmse:0.102662
## [471]    train-rmse:0.010661 test-rmse:0.102665
## [472]    train-rmse:0.010657 test-rmse:0.102662
## [473]    train-rmse:0.010649 test-rmse:0.102667
## [474]    train-rmse:0.010607 test-rmse:0.102677
## [475]    train-rmse:0.010598 test-rmse:0.102684
```

#It apears that the number of iterations that reduce test and training rmse is 1963

```
final_boost2<-xgboost(data = xgb_train, max.depth = 3, nrounds = 464, verbose = 0)
prediction2<-predict(final_boost2, as.matrix(test_px))
#print(prediction)
prediction2<-round(prediction2,0)
```

```r
#prediction

cm2<-cm_knn<-(confusionMatrix(data = factor(prediction2), reference = factor(test_py)))
cm2
```

```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18
##         1  19  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
##         2   0 15  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
##         3   0  0 25  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
##         4   0  0  0 13  0  0  0  0  0  0  0  0  0  0  0  0  0  0
##         5   0  0  0  0 27  1  0  0  0  0  0  0  0  0  0  0  0  0
##         6   0  0  0  0  0  8  0  0  0  0  0  0  0  0  0  0  0  0
##         7   0  0  0  0  0  0 10  0  0  0  0  0  0  0  0  0  0  0
##         8   0  0  0  0  0  0  0  9  0  0  0  0  0  0  0  0  0  0
##         9   0  0  0  0  0  0  0  0  8  0  0  0  0  0  0  0  0  0
##         10  0  0  0  0  0  0  0  0  0  7  0  0  0  0  0  0  0  0
##         11  0  0  0  0  0  0  0  0  0  0  7  0  0  0  0  0  0  0
##         12  0  0  0  0  0  0  0  0  0  0  0  9  0  0  0  0  0  0
##         13  0  0  0  0  0  0  0  0  0  0  0  0  8  0  0  0  0  0
##         14  0  0  0  0  0  0  0  0  0  0  0  0  0 16  0  0  0  0
##         15  0  0  0  0  0  0  0  0  0  0  0  0  0  0  9  0  0  0
##         16  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0 11  0  0
##         17  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  9  0
##         18  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  1
##
## Overall Statistics
##
##                Accuracy : 0.9953
##                  95% CI : (0.974, 0.9999)
##     No Information Rate : 0.1274
##     P-Value [Acc > NIR] : < 2.2e-16
##
##                   Kappa : 0.9949
##
##  Mcnemar's Test P-Value : NA
##
## Statistics by Class:
##
##                      Class: 1 Class: 2 Class: 3 Class: 4 Class: 5 Class: 6
## Sensitivity           1.00000  1.00000   1.0000  1.00000   1.0000  0.88889
## Specificity           1.00000  1.00000   1.0000  1.00000   0.9946  1.00000
## Pos Pred Value        1.00000  1.00000   1.0000  1.00000   0.9643  1.00000
## Neg Pred Value        1.00000  1.00000   1.0000  1.00000   1.0000  0.99510
## Prevalence            0.08962  0.07075   0.1179  0.06132   0.1274  0.04245
## Detection Rate        0.08962  0.07075   0.1179  0.06132   0.1274  0.03774
## Detection Prevalence  0.08962  0.07075   0.1179  0.06132   0.1321  0.03774
## Balanced Accuracy     1.00000  1.00000   1.0000  1.00000   0.9973  0.94444
##                      Class: 7 Class: 8 Class: 9 Class: 10 Class: 11 Class: 12
## Sensitivity           1.00000  1.00000  1.00000   1.00000   1.00000   1.00000
## Specificity           1.00000  1.00000  1.00000   1.00000   1.00000   1.00000
## Pos Pred Value        1.00000  1.00000  1.00000   1.00000   1.00000   1.00000
```

```
## Neg Pred Value        1.00000  1.00000  1.00000   1.00000   1.00000   1.00000
## Prevalence            0.04717  0.04245  0.03774   0.03302   0.03302   0.04245
## Detection Rate        0.04717  0.04245  0.03774   0.03302   0.03302   0.04245
## Detection Prevalence  0.04717  0.04245  0.03774   0.03302   0.03302   0.04245
## Balanced Accuracy     1.00000  1.00000  1.00000   1.00000   1.00000   1.00000
##                      Class: 13 Class: 14 Class: 15 Class: 16 Class: 17
## Sensitivity            1.00000   1.00000   1.00000   1.00000   1.00000
## Specificity            1.00000   1.00000   1.00000   1.00000   1.00000
## Pos Pred Value         1.00000   1.00000   1.00000   1.00000   1.00000
## Neg Pred Value         1.00000   1.00000   1.00000   1.00000   1.00000
## Prevalence             0.03774   0.07547   0.04245   0.05189   0.04245
## Detection Rate         0.03774   0.07547   0.04245   0.05189   0.04245
## Detection Prevalence   0.03774   0.07547   0.04245   0.05189   0.04245
## Balanced Accuracy      1.00000   1.00000   1.00000   1.00000   1.00000
##                      Class: 18
## Sensitivity           1.000000
## Specificity           1.000000
## Pos Pred Value        1.000000
## Neg Pred Value        1.000000
## Prevalence            0.004717
## Detection Rate        0.004717
## Detection Prevalence  0.004717
## Balanced Accuracy     1.000000
```