Predicting Pitcher DL

Roger Chow

April 16, 2017

Load libraries

```
setwd("F:/Capstone_Workspace/predictDL/");
library('RODBC');
library('DBI');
library('plyr');
library('dplyr');
```

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

```
## The following objects are masked from 'package:plyr':
##
##     arrange, count, desc, failwith, id, mutate, rename, summarise,
##     summarize
```

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

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

```
library('stringi');
library('sqldf');
```

```
## Loading required package: gsubfn
```

```
## Loading required package: proto
```

```
## Loading required package: RSQLite
```

```
library('corrplot');
library('reshape2');
library('lattice');
library('ggplot2');
library('caret');
library('logistf');
library('klaR');
```

```
## Loading required package: MASS
```

```
##
## Attaching package: 'MASS'

## The following object is masked from 'package:dplyr':
##
##     select

library('pROC');

## Type 'citation("pROC")' for a citation.

##
## Attaching package: 'pROC'

## The following objects are masked from 'package:stats':
##
##     cov, smooth, var

library('pls');

##
## Attaching package: 'pls'

## The following object is masked from 'package:corrplot':
##
##     corrplot

## The following object is masked from 'package:stats':
##
##     loadings

library('ROSE');

## Loaded ROSE 0.0-3

library('randomForest')

## randomForest 4.6-12

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

##
## Attaching package: 'randomForest'

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

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

resetPar <- function() {
    dev.new()
```

```
    op <- par(no.readonly = TRUE)
    dev.off()
    op
}

par(resetPar());
```

Prepare data

Load from Cache

Load the data from cache if the cache exists. This is will save time when re-running the analysis since the data will not change. It takes approximately 30 minutes to load the data from scratch.

```
need_load <- TRUE;
if (file.exists("pitches_dl_dataset.csv")){
  pitches_dl_dataset <- read.csv("pitches_dl_dataset.csv");
  pitches_dl_predict <- read.csv("pitches_dl_predict.csv");


  drops <- c("X");
  pitches_dl_dataset <- pitches_dl_dataset[ , !(names(pitches_dl_dataset) %in
% drops)];
  pitches_dl_predict <- pitches_dl_predict[ , !(names(pitches_dl_predict) %in
% drops)];

  need_load <- FALSE;
}
```

Load pitchFX data from Database

If there is data cached, load the data from the SQL Server database.

Impute missing values using the Median.

The median is used to measure the central tendency for each continuous variable for each pitcher. The count of the pitch types is also calculate for each pitcher in each year.

```
if (need_load) {
  years <- c(2010, 2011, 2012, 2013, 2014, 2015, 2016);

  dbhandle <- odbcDriverConnect('driver={SQL Server};server=localhost;databas
e=PitchFx;trusted_connection=true');

  impute <- function(x, fun) {
    missing <- is.na(x)
    replace(x, missing, fun(x[!missing]))
```

```
  }


  centroid_fun <- median;
  impute_fun <- median;


  for (i in 2010:2016)
  {
    query <-
   paste("SELECT    ", i, " as season, m.rsID, p.id, p.atbatid, a.pitcher,
            p.x, p.y, p.start_speed, p.end_speed, p.sz_top, p.sz_bot,
            p.px, p.pz, p.x0, p.y0, p.z0, p.vx0, p.vy0, p.vz0, p.ax, p.ay, p.
az,
            p.break_y, p.break_length, p.spin_dir, p.spin_rate,
            1 as type_ALL,
            CASE WHEN ISNULL(p.pitch_type,'UN') = 'AB' THEN 1 ELSE 0 END AS t
ype_AB,
            CASE WHEN ISNULL(p.pitch_type,'UN') = 'AS' THEN 1 ELSE 0 END AS t
ype_AS,
            CASE WHEN ISNULL(p.pitch_type,'UN') = 'CH' THEN 1 ELSE 0 END AS t
ype_CH,
            CASE WHEN ISNULL(p.pitch_type,'UN') = 'CU' THEN 1 ELSE 0 END AS t
ype_CU,
            CASE WHEN ISNULL(p.pitch_type,'UN') = 'EP' THEN 1 ELSE 0 END AS t
ype_EP,
            CASE WHEN ISNULL(p.pitch_type,'UN') = 'FA' THEN 1 ELSE 0 END AS t
ype_FA,
            CASE WHEN ISNULL(p.pitch_type,'UN') = 'FC' THEN 1 ELSE 0 END AS t
ype_FC,
            CASE WHEN ISNULL(p.pitch_type,'UN') = 'FF' THEN 1 ELSE 0 END AS t
ype_FF,
            CASE WHEN ISNULL(p.pitch_type,'UN') = 'FO' THEN 1 ELSE 0 END AS t
ype_FO,
            CASE WHEN ISNULL(p.pitch_type,'UN') = 'FS' THEN 1 ELSE 0 END AS t
ype_FS,
            CASE WHEN ISNULL(p.pitch_type,'UN') = 'FT' THEN 1 ELSE 0 END AS t
ype_FT,
            CASE WHEN ISNULL(p.pitch_type,'UN') = 'IN' THEN 1 ELSE 0 END AS t
ype_IN,
            CASE WHEN ISNULL(p.pitch_type,'UN') = 'KC' THEN 1 ELSE 0 END AS t
ype_KC,
            CASE WHEN ISNULL(p.pitch_type,'UN') = 'KN' THEN 1 ELSE 0 END AS t
ype_KN,
            CASE WHEN ISNULL(p.pitch_type,'UN') = 'PO' THEN 1 ELSE 0 END AS t
ype_PO,
            CASE WHEN ISNULL(p.pitch_type,'UN') = 'SC' THEN 1 ELSE 0 END AS t
ype_SC,
            CASE WHEN ISNULL(p.pitch_type,'UN') = 'SI' THEN 1 ELSE 0 END AS t
```

```
ype_SI,
            CASE WHEN ISNULL(p.pitch_type,'UN') = 'SL' THEN 1 ELSE 0 END AS t
ype_SL,
            CASE WHEN ISNULL(p.pitch_type,'UN') not in ('AS', 'CH', 'CU', 'EP
', 'FA', 'FC', 'FF', 'FO', 'FS', 'FT', 'IN', 'KC', 'KN', 'PO', 'SC', 'SI') TH
EN 1 ELSE 0 END as type_UN
          FROM [PitchFx",i,"].[dbo].[Pitches] p
          INNER JOIN [PitchFx",i,"].[dbo].[AtBats] a on a.ID = p.AtBatID
          INNER JOIN [Mapping].[dbo].[RSID_MLBID_MAP] m on a.pitcher = m.mlbi
d
          INNER JOIN [Lahman].[dbo].[Master] ms on ms.retroID = m.rsID", sep=
"");

    pitches_raw <-sqlQuery(dbhandle, query);


    pitches_impute_centroid <- ddply(pitches_raw, ~rsID, transform,
                    x = impute(x, impute_fun),
                    y = impute(y, impute_fun),
                    start_speed = impute(start_speed, impute_fun),
                    end_speed = impute(end_speed, impute_fun),
                    sz_top = impute(sz_top, impute_fun),
                    sz_bot = impute(sz_bot, impute_fun),
                    px = impute(px, impute_fun),
                    pz = impute(pz, impute_fun),
                    x0 = impute(x0, impute_fun),
                    y0 = impute(y0, impute_fun),
                    z0 = impute(z0, impute_fun),
                    vx0 = impute(vx0, impute_fun),
                    vy0 = impute(vy0, impute_fun),
                    vz0 = impute(vz0, impute_fun),
                    ax = impute(ax, impute_fun),
                    ay = impute(ay, impute_fun),
                    az = impute(az, impute_fun),
                    break_y = impute(break_y, impute_fun),
                    break_length = impute(break_length, impute_fun),
                    spin_dir = impute(spin_dir, impute_fun),
                    spin_rate =  impute(spin_rate, impute_fun)
                    );

   pitches_aggregate <- ddply(pitches_impute_centroid, ~rsID, summarise,
                    season = max(season),
                    x  = centroid_fun(x),
                    y = centroid_fun(y),
                    start_speed = centroid_fun(start_speed),
                    end_speed = centroid_fun(end_speed),
                    sz_top = centroid_fun(sz_top),
                    sz_bot = centroid_fun(sz_bot),
                    px = centroid_fun(px),
```

```
                    pz = centroid_fun(pz),
                    x0 = centroid_fun(x0),
                    y0 = centroid_fun(y0),
                    z0 = centroid_fun(z0),
                    vx0 = centroid_fun(vx0),
                    vy0 = centroid_fun(vy0),
                    vz0 = centroid_fun(vz0),
                    ax = centroid_fun(ax),
                    ay = centroid_fun(ay),
                    az = centroid_fun(az),
                    break_y = centroid_fun(break_y),
                    break_length = centroid_fun(break_length),
                    spin_dir = centroid_fun(spin_dir),
                    spin_rate =  centroid_fun(spin_rate),
                    num_pitches = sum(type_ALL),
                    num_AB = sum(type_AB),
                    num_AS = sum(type_AS),
                    num_CH = sum(type_CH),
                    num_CU = sum(type_CU),
                    num_EP = sum(type_EP),
                    num_FA = sum(type_FA),
                    num_FC = sum(type_FC),
                    num_FF = sum(type_FF),
                    num_FO = sum(type_FO),
                    num_FS = sum(type_FS),
                    num_FT = sum(type_FT),
                    num_IN = sum(type_IN),
                    num_KC = sum(type_KC),
                    num_KN = sum(type_KN),
                    num_PO = sum(type_PO),
                    num_SC = sum(type_SC),
                    num_SI = sum(type_SI),
                    num_SL = sum(type_SL),
                    num_UN = sum(type_UN)
                    );

    assign(paste("pitches",i,sep=""), pitches_aggregate);

  };

  pitches <- rbind(pitches2010, pitches2011, pitches2012, pitches2013, pitche
s2014, pitches2015, pitches2016);
  pitches <- pitches[complete.cases(pitches),];


  close(dbhandle);
}
```

Load the disabled this

If there is no data cached, load the disable list data from the SQL Server database.

This data contains the list of pitchers on the disable list in each year. Define a new column for season_1 to denote the previous season. This is required since the pitching data from the previous season will be used to determine if the player will be on the disabled list in the current season.

```
 if (need_load) {
  dbhandle <- odbcDriverConnect('driver={SQL Server};server=localhost;databas
e=PitchFx;trusted_connection=true');
  query <- "
  SELECT rsid, 2011 as season_dl, sum(days) as DLDays
    FROM [DisabledList].[dbo].[DL2011]
    WHERE Position in ('LHP','RHP','RP','SP','P')
    GROUP BY rsid
  UNION
  SELECT rsid, 2012 as season_dl, sum(days) as DLDays
    FROM [DisabledList].[dbo].[DL2012]
    WHERE Pos in ('LHP','RHP','RP','SP','P')
    GROUP BY rsid
  UNION
  SELECT rsid, 2013 as season_dl, sum(days) as DLDays
    FROM [DisabledList].[dbo].[DL2013]
    WHERE Position in ('LHP','RHP','RP','SP','P')
    GROUP BY rsid
  UNION
  SELECT rsid, 2014 as season_dl, sum(days) as DLDays
    FROM [DisabledList].[dbo].[DL2014]
    WHERE Position in ('LHP','RHP','RP','SP','P')
    GROUP BY rsid
  UNION
  SELECT rsid, 2015 as season_dl, sum(days) as DLDays
    FROM [DisabledList].[dbo].[DL2015]
    WHERE Position in ('LHP','RHP','RP','SP','P')
    GROUP BY rsid
  UNION
  SELECT rsid, 2016 as season_dl, sum(days) as DLDays
    FROM [DisabledList].[dbo].[DL2016]
    WHERE Position in ('LHP','RHP','RP','SP','P')
    GROUP BY rsid
  ";

  dl <- sqlQuery(dbhandle, query);
  dl <- dl[complete.cases(dl),];
  dl$season_1 <- dl$season-1;
  close(dbhandle);
 }
```

Join the pitch and disabled list data

If there is no data cached, join the pitching data and disabled list data by season.

Define the response variable OnDL to be TRUE if the pitcher is was on the disabled list or FALSE otherwise.

The pitching data from seasons 2010 to 2015 will be used to build and test the model since the disabled list is only available up to the 2016 season.

The pitching data from 2016 will be used to predict which players are most likey be on the disable list in 2017.

```
if (need_load) {
  #use previous season to predict DL in current season
  pitches_dl <- merge(x=pitches, y=dl, by.x=c("rsID", "season"), by.y=c("rsid
", "season_1"), all.x = TRUE, all.y=FALSE)

  pitches_dl[pitches_dl==""] <- NA; #replace blanks with NA

  pitches_dl$DLDays[is.na(pitches_dl$DLDays)] <- 0; #no DL pitchers are on DL
for 0 days
  pitches_dl$OnDL <- (ifelse(pitches_dl$DLDays>0, 1, 0));

  drops <- c("season_dl", "DLDays");
  pitches_dl <- pitches_dl[ , !(names(pitches_dl) %in% drops)];

  pitches_dl <- pitches_dl[complete.cases(pitches_dl),];

  pitches_dl_dataset <- pitches_dl[pitches_dl$season < 2016,]; #for modeling
  pitches_dl_predict <- pitches_dl[pitches_dl$season == 2016,]; #for 2017 pre
diction

  #pitches_dl_dataset$OnDL <- as.factor(ifelse(pitches_dl_dataset$DLDays>0, '
YES', 'NO'));



  drops <- c("season");
  pitches_dl_dataset <- pitches_dl_dataset[ , !(names(pitches_dl_dataset) %in
% drops)];
  pitches_dl_predict <- pitches_dl_predict[ , !(names(pitches_dl_predict) %in
% drops)];



  #write to csv to save time
  write.csv(pitches_dl_dataset, "pitches_dl_dataset.csv");
  write.csv(pitches_dl_predict, "pitches_dl_predict.csv");

}
```

Transform count variables

Apply Anscombe transformation to count variables

```
trf_func <- function(x) {
  return ( 2*sqrt(x+3/8));
  #return ( log(x+1));
}

pitches_dl_dataset$trf_num_pitches <- trf_func(pitches_dl_dataset$num_pitches
);
pitches_dl_predict$trf_num_pitches <- trf_func(pitches_dl_predict$num_pitches
);
#
# for (t in c("AB", "AS", "CH", "CU", "EP", "FA", "FC", "FF", "FO", "FS", "FT
", "IN","KC", "KN", "PO", "SC", "SI", "SL", "UN"))
# {
#   expression <-  paste("pitches_dl_dataset$num_", t, sep="");
#   eval_expression <- eval(parse(text=expression)) /pitches_dl_dataset$num_p
itches;
#   assign_var = paste("pitches_dl_dataset$trf_num_", t, sep="");
#   assign(assign_var,  eval_expression)
#
#   expression <-  paste("pitches_dl_dataset$num_", t, sep="");
#   eval_expression <- eval(parse(text=expression))/pitches_dl_predict$num_pi
tches;
#   assign_var = paste("pitches_dl_predict$trf_num_", t, sep="");
#   assign(assign_var,  eval_expression)
#
# }


pitches_dl_dataset$trf_num_AB <- trf_func(pitches_dl_dataset$num_AB)
pitches_dl_dataset$trf_num_AS <- trf_func(pitches_dl_dataset$num_AS)
pitches_dl_dataset$trf_num_CH <- trf_func(pitches_dl_dataset$num_CH)
pitches_dl_dataset$trf_num_CU <- trf_func(pitches_dl_dataset$num_CU)
pitches_dl_dataset$trf_num_EP <- trf_func(pitches_dl_dataset$num_EP)
pitches_dl_dataset$trf_num_FA <- trf_func(pitches_dl_dataset$num_FA)
pitches_dl_dataset$trf_num_FC <- trf_func(pitches_dl_dataset$num_FC)
pitches_dl_dataset$trf_num_FF <- trf_func(pitches_dl_dataset$num_FF)
pitches_dl_dataset$trf_num_FO <- trf_func(pitches_dl_dataset$num_FO)
pitches_dl_dataset$trf_num_FS <- trf_func(pitches_dl_dataset$num_FS)
pitches_dl_dataset$trf_num_FT <- trf_func(pitches_dl_dataset$num_FT)
pitches_dl_dataset$trf_num_IN <- trf_func(pitches_dl_dataset$num_IN)
pitches_dl_dataset$trf_num_KC <- trf_func(pitches_dl_dataset$num_KC)
pitches_dl_dataset$trf_num_KN <- trf_func(pitches_dl_dataset$num_KN)
pitches_dl_dataset$trf_num_PO <- trf_func(pitches_dl_dataset$num_PO)
pitches_dl_dataset$trf_num_SC <- trf_func(pitches_dl_dataset$num_SC)
pitches_dl_dataset$trf_num_SI <- trf_func(pitches_dl_dataset$num_SI)
pitches_dl_dataset$trf_num_SL <- trf_func(pitches_dl_dataset$num_SL)
```

```
pitches_dl_dataset$trf_num_UN <- trf_func(pitches_dl_dataset$num_UN)

pitches_dl_predict$trf_num_AB <- trf_func(pitches_dl_predict$num_AB)
pitches_dl_predict$trf_num_AS <- trf_func(pitches_dl_predict$num_AS)
pitches_dl_predict$trf_num_CH <- trf_func(pitches_dl_predict$num_CH)
pitches_dl_predict$trf_num_CU <- trf_func(pitches_dl_predict$num_CU)
pitches_dl_predict$trf_num_EP <- trf_func(pitches_dl_predict$num_EP)
pitches_dl_predict$trf_num_FA <- trf_func(pitches_dl_predict$num_FA)
pitches_dl_predict$trf_num_FC <- trf_func(pitches_dl_predict$num_FC)
pitches_dl_predict$trf_num_FF <- trf_func(pitches_dl_predict$num_FF)
pitches_dl_predict$trf_num_FO <- trf_func(pitches_dl_predict$num_FO)
pitches_dl_predict$trf_num_FS <- trf_func(pitches_dl_predict$num_FS)
pitches_dl_predict$trf_num_FT <- trf_func(pitches_dl_predict$num_FT)
pitches_dl_predict$trf_num_IN <- trf_func(pitches_dl_predict$num_IN)
pitches_dl_predict$trf_num_KC <- trf_func(pitches_dl_predict$num_KC)
pitches_dl_predict$trf_num_KN <- trf_func(pitches_dl_predict$num_KN)
pitches_dl_predict$trf_num_PO <- trf_func(pitches_dl_predict$num_PO)
pitches_dl_predict$trf_num_SC <- trf_func(pitches_dl_predict$num_SC)
pitches_dl_predict$trf_num_SI <- trf_func(pitches_dl_predict$num_SI)
pitches_dl_predict$trf_num_SL <- trf_func(pitches_dl_predict$num_SL)
pitches_dl_predict$trf_num_UN <- trf_func(pitches_dl_predict$num_UN)



model_dataset <- pitches_dl_dataset[,-grep( "^num_" , names( pitches_dl_datas
et ) )];
predict_dataset <- pitches_dl_predict[,-grep( "^num_" , names( pitches_dl_pre
dict ) )];
```

Exploratory Analysis

Summary of data set

List of variables

```
dependent_var <- colnames(model_dataset[,-grep( "^OnDL" , names( model_datase
t ) )])[-1];
original_var <- dependent_var[1:22];
count_var <- dependent_var[22:40];
response_var <- "OnDL";
```

Summary of continous variables

```
summary(model_dataset[which(colnames(model_dataset) %in% original_var)]);

##        x                y          start_speed     end_speed
##  Min.   : 75.54   Min.   : 97.7   Min.   :53.9   Min.   :49.80
##  1st Qu.: 97.86   1st Qu.:145.1   1st Qu.:87.5   1st Qu.:80.70
##  Median :102.15   Median :148.5   Median :89.8   Median :82.70
##  Mean   :103.65   Mean   :151.0   Mean   :89.4   Mean   :82.33
```

```
##  3rd Qu.:107.30   3rd Qu.:152.8   3rd Qu.:91.9   3rd Qu.:84.50
##  Max.   :139.98   Max.   :195.7   Max.   :99.4   Max.   :91.10
##      sz_top          sz_bot            px                pz
##  Min.   :0.000   Min.   :0.000   Min.   :-1.43400   Min.   :1.185
##  1st Qu.:3.390   1st Qu.:1.550   1st Qu.:-0.18875   1st Qu.:2.194
##  Median :3.420   Median :1.580   Median :-0.06750   Median :2.322
##  Mean   :3.416   Mean   :1.583   Mean   :-0.07214   Mean   :2.334
##  3rd Qu.:3.450   3rd Qu.:1.610   3rd Qu.: 0.05550   3rd Qu.:2.459
##  Max.   :3.750   Max.   :1.805   Max.   : 1.33350   Max.   :3.638
##        x0               y0           z0             vx0
##  Min.   :-4.085   Min.   :50   Min.   :1.960   Min.   :-15.965
##  1st Qu.:-2.030   1st Qu.:50   1st Qu.:5.643   1st Qu.: -4.080
##  Median :-1.381   Median :50   Median :5.894   Median :  4.511
##  Mean   :-0.717   Mean   :50   Mean   :5.854   Mean   :  2.084
##  3rd Qu.: 1.047   3rd Qu.:50   3rd Qu.:6.136   3rd Qu.:  6.216
##  Max.   : 5.229   Max.   :50   Max.   :7.306   Max.   : 11.441
##       vy0              vz0               ax               ay
##  Min.   :-145.42   Min.   :-9.690   Min.   :-23.480   Min.   :10.34
##  1st Qu.:-134.48   1st Qu.:-5.546   1st Qu.:-10.075   1st Qu.:25.43
##  Median :-131.43   Median :-4.654   Median : -5.433   Median :26.93
##  Mean   :-130.83   Mean   :-4.445   Mean   : -2.959   Mean   :26.98
##  3rd Qu.:-128.08   3rd Qu.:-3.641   3rd Qu.:  4.211   3rd Qu.:28.60
##  Max.   : -78.97   Max.   :10.264   Max.   : 22.284   Max.   :35.57
##        az            break_y      break_length       spin_dir
##  Min.   :-44.314   Min.   :23.7   Min.   : 2.600   Min.   : 70.01
##  1st Qu.:-24.074   1st Qu.:23.8   1st Qu.: 4.900   1st Qu.:161.16
##  Median :-20.948   Median :23.8   Median : 5.800   Median :200.38
##  Mean   :-21.181   Mean   :23.8   Mean   : 5.884   Mean   :191.94
##  3rd Qu.:-17.874   3rd Qu.:23.8   3rd Qu.: 6.700   3rd Qu.:217.43
##  Max.   : -6.576   Max.   :23.9   Max.   :16.650   Max.   :325.10
##    spin_rate      trf_num_pitches
##  Min.   : 445.4   Min.   :  2.345
##  1st Qu.:1663.2   1st Qu.: 29.521
##  Median :1867.4   Median : 54.346
##  Mean   :1846.9   Mean   : 56.209
##  3rd Qu.:2053.3   3rd Qu.: 72.811
##  Max.   :3000.0   Max.   :133.287
```

Summary of count variables after transforming

```
summary(model_dataset[which(colnames(model_dataset) %in% count_var)]);
```

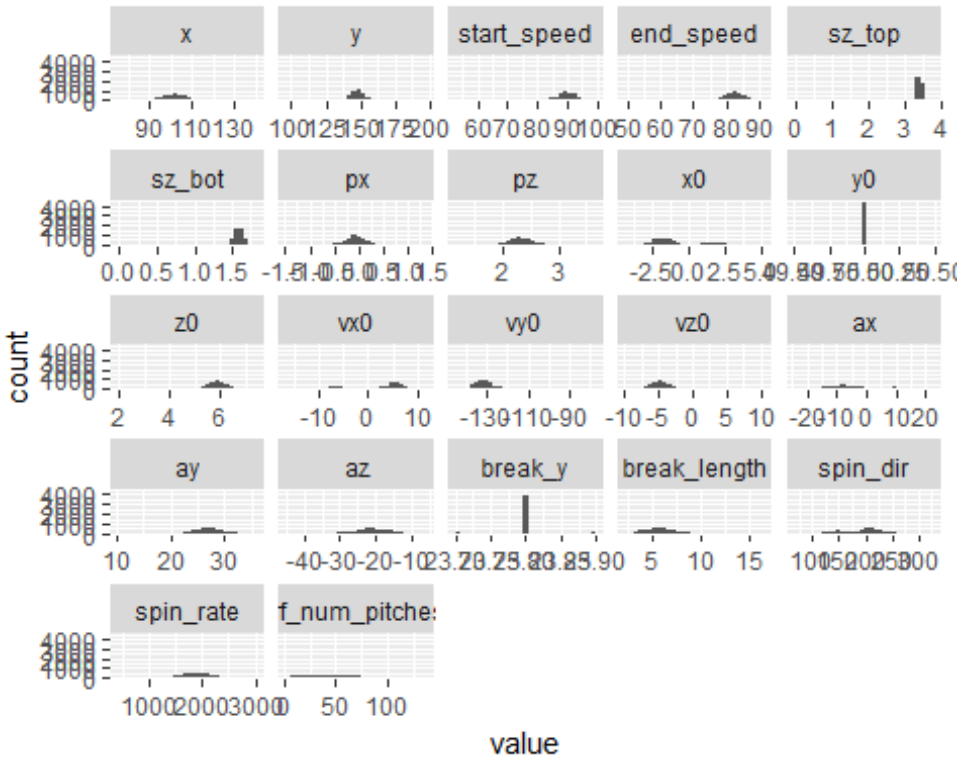
```
##  trf_num_pitches     trf_num_AB      trf_num_AS      trf_num_CH
##  Min.   :  2.345   Min.   :1.225   Min.   :1.225   Min.   : 1.225
##  1st Qu.: 29.521   1st Qu.:1.225   1st Qu.:1.225   1st Qu.: 3.674
##  Median : 54.346   Median :1.225   Median :1.225   Median :10.464
##  Mean   : 56.209   Mean   :1.227   Mean   :1.225   Mean   :14.888
##  3rd Qu.: 72.811   3rd Qu.:1.225   3rd Qu.:1.225   3rd Qu.:22.749
##  Max.   :133.287   Max.   :2.345   Max.   :2.345   Max.   :67.775
##    trf_num_CU       trf_num_EP       trf_num_FA       trf_num_FC
##  Min.   : 1.225   Min.   : 1.225   Min.   : 1.225   Min.   : 1.225
```

```
##  1st Qu.: 1.225   1st Qu.: 1.225   1st Qu.: 1.225   1st Qu.: 1.225
##  Median : 4.637   Median : 1.225   Median : 1.225   Median : 1.225
##  Mean   :11.697   Mean   : 1.322   Mean   : 1.345   Mean   : 7.299
##  3rd Qu.:19.532   3rd Qu.: 1.225   3rd Qu.: 1.225   3rd Qu.: 5.431
##  Max.   :68.129   Max.   :27.009   Max.   :16.778   Max.   :87.416
##    trf_num_FF       trf_num_FO       trf_num_FS       trf_num_FT
##  Min.   : 1.225   Min.   : 1.225   Min.   : 1.225   Min.   : 1.225
##  1st Qu.:11.380   1st Qu.: 1.225   1st Qu.: 1.225   1st Qu.: 1.225
##  Median :26.486   Median : 1.225   Median : 1.225   Median : 6.124
##  Mean   :29.871   Mean   : 1.293   Mean   : 3.100   Mean   :13.998
##  3rd Qu.:44.917   3rd Qu.: 1.225   3rd Qu.: 1.225   3rd Qu.:21.852
##  Max.   :98.881   Max.   :35.405   Max.   :64.942   Max.   :86.357
##    trf_num_IN       trf_num_KC       trf_num_KN       trf_num_PO
##  Min.   : 1.225   Min.   : 1.225   Min.   :  1.225   Min.   :1.225
##  1st Qu.: 1.225   1st Qu.: 1.225   1st Qu.:  1.225   1st Qu.:1.225
##  Median : 3.674   Median : 1.225   Median :  1.225   Median :1.225
##  Mean   : 3.744   Mean   : 3.060   Mean   :  1.472   Mean   :1.724
##  3rd Qu.: 5.788   3rd Qu.: 1.225   3rd Qu.:  1.225   3rd Qu.:2.345
##  Max.   :13.019   Max.   :67.420   Max.   :108.247   Max.   :7.842
##    trf_num_SC       trf_num_SI       trf_num_SL
##  Min.   : 1.225   Min.   : 1.225   Min.   : 1.225
##  1st Qu.: 1.225   1st Qu.: 1.225   1st Qu.: 3.082
##  Median : 1.225   Median : 1.225   Median :14.748
##  Mean   : 1.252   Mean   :10.211   Mean   :18.245
##  3rd Qu.: 1.225   3rd Qu.: 7.583   3rd Qu.:29.521
##  Max.   :20.821   Max.   :98.982   Max.   :78.521
```

Histogram of data

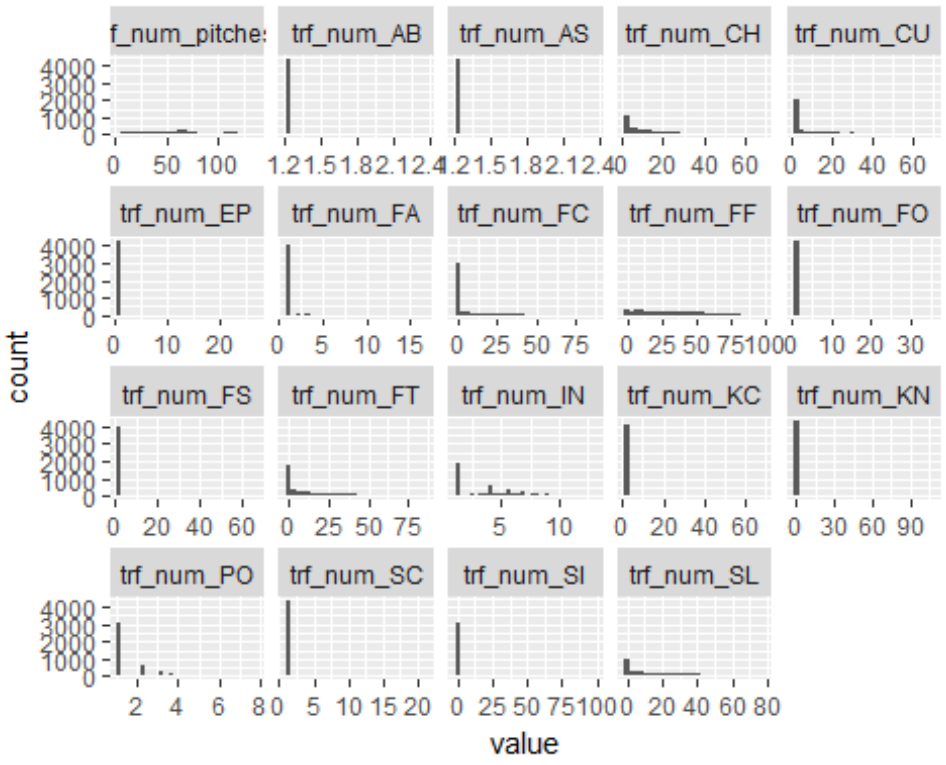
Continuous Variables

```
d <- melt(model_dataset[which(colnames(model_dataset) %in% original_var)]);

## No id variables; using all as measure variables

ggplot(d,aes(x = value)) + facet_wrap(~variable,scales = "free_x") +  geom_hi
stogram();

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



Count Variables

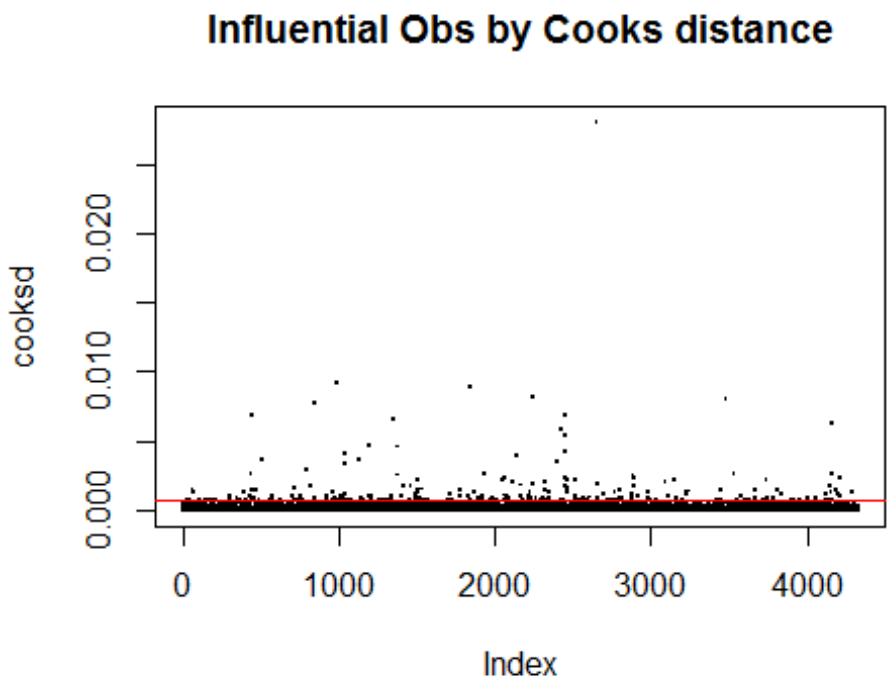
```
d <- melt(model_dataset[which(colnames(model_dataset) %in% count_var)]);

## No id variables; using all as measure variables

ggplot(d,aes(x = value)) + facet_wrap(~variable,scales = "free_x") +  geom_hi
stogram();

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



Outliers

(1) Fox, John. (1991). Regression Diagnostics: An Introduction. Sage Publications.

```
selected_variables <- dependent_var;

selected_i <- which(colnames(model_dataset) %in% selected_variables);

formula_text <- paste(response_var, "~",
                      paste(names(model_dataset)[selected_i], collapse="+"));
formula <- as.formula(formula_text);

mod <- glm(formula=formula, data=model_dataset);
cooksd <- cooks.distance(mod);

plot(cooksd, pch=".", cex=2, main="Influential Obs by Cooks distance");  # pl
ot cook's distance
abline(h = 3*mean(cooksd, na.rm=T), col="red");  # add cutoff line
```




```
# text(x=1:length(cooksd)+1, y=cooksd, labels=ifelse(cooksd>10*mean(cooksd, n
a.rm=T),names(cooksd),""), col="red")
```

Remove outliers

```
influential <- as.numeric(names(cooksd)[(cooksd > 3*mean(cooksd, na.rm=T))]);

model_dataset_lessOutliers <- model_dataset[-(influential[!is.na(influential)
]), ];
```

Summary of data after outliers removed

```
summary(model_dataset_lessOutliers);
```

```
##        rsID            x                y          start_speed
##  abadf001:   6   Min.   : 75.54   Min.   : 97.7   Min.   :53.90
##  adamm001:   6   1st Qu.: 97.85   1st Qu.:145.1   1st Qu.:87.60
##  affej001:   6   Median :102.15   Median :148.5   Median :89.85
##  albem001:   6   Mean   :103.63   Mean   :150.9   Mean   :89.47
##  arrij001:   6   3rd Qu.:107.30   3rd Qu.:152.8   3rd Qu.:91.90
##  atchs001:   6   Max.   :139.98   Max.   :195.7   Max.   :99.40
##  (Other) :4084
##    end_speed         sz_top          sz_bot            px
##  Min.   :49.80   Min.   :0.000   Min.   :0.000   Min.   :-1.43400
##  1st Qu.:80.70   1st Qu.:3.390   1st Qu.:1.550   1st Qu.:-0.18862
##  Median :82.70   Median :3.420   Median :1.580   Median :-0.06750
##  Mean   :82.39   Mean   :3.418   Mean   :1.584   Mean   :-0.07198
##  3rd Qu.:84.50   3rd Qu.:3.450   3rd Qu.:1.610   3rd Qu.: 0.05563
```

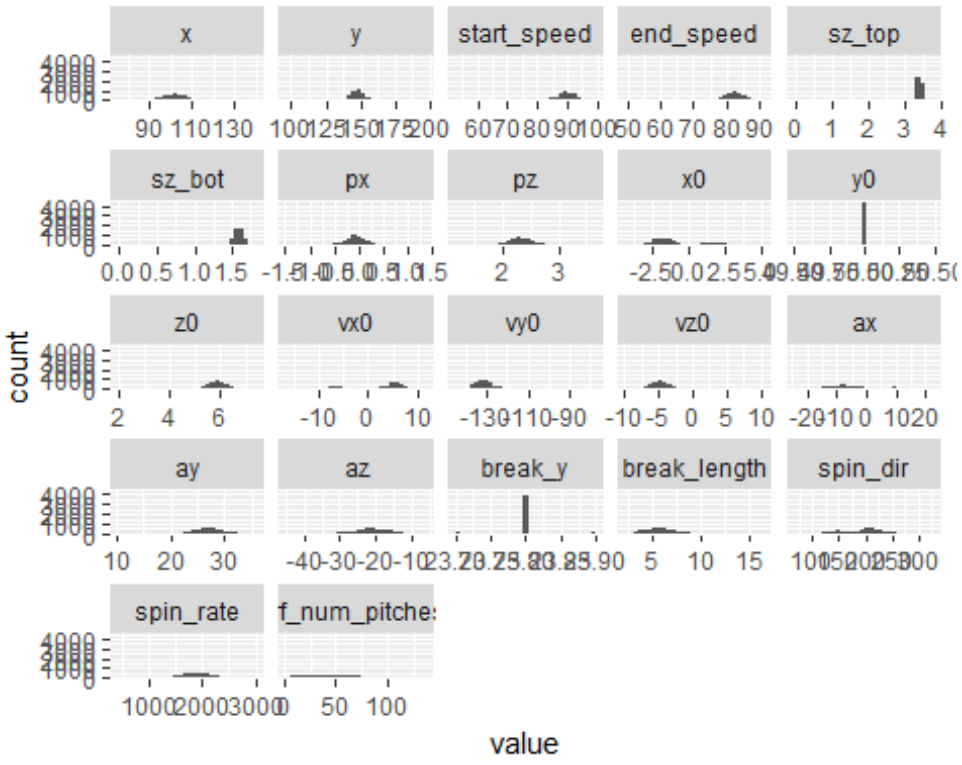
```
##  Max.   :91.10   Max.   :3.750   Max.   :1.805   Max.   : 1.33350
##
##       pz              x0               y0           z0
##  Min.   :1.185   Min.   :-4.0845   Min.   :50   Min.   :1.960
##  1st Qu.:2.197   1st Qu.:-2.0326   1st Qu.:50   1st Qu.:5.649
##  Median :2.323   Median :-1.3820   Median :50   Median :5.897
##  Mean   :2.335   Mean   :-0.7262   Mean   :50   Mean   :5.860
##  3rd Qu.:2.460   3rd Qu.: 1.0146   3rd Qu.:50   3rd Qu.:6.137
##  Max.   :3.638   Max.   : 5.2295   Max.   :50   Max.   :7.306
##
##      vx0              vy0              vz0               ax
##  Min.   :-15.965   Min.   :-145.42   Min.   :-9.690   Min.   :-23.480
##  1st Qu.: -3.996   1st Qu.:-134.50   1st Qu.:-5.558   1st Qu.:-10.087
##  Median :  4.506   Median :-131.50   Median :-4.671   Median : -5.486
##  Mean   :  2.113   Mean   :-130.93   Mean   :-4.483   Mean   : -3.003
##  3rd Qu.:  6.231   3rd Qu.:-128.19   3rd Qu.:-3.680   3rd Qu.:  4.138
##  Max.   : 11.441   Max.   : -78.97   Max.   :10.264   Max.   : 22.284
##
##       ay              az             break_y      break_length
##  Min.   :10.34   Min.   :-44.314   Min.   :23.7   Min.   : 2.600
##  1st Qu.:25.47   1st Qu.:-23.965   1st Qu.:23.8   1st Qu.: 4.900
##  Median :26.95   Median :-20.862   Median :23.8   Median : 5.700
##  Mean   :27.00   Mean   :-21.074   Mean   :23.8   Mean   : 5.848
##  3rd Qu.:28.62   3rd Qu.:-17.827   3rd Qu.:23.8   3rd Qu.: 6.700
##  Max.   :35.44   Max.   : -8.132   Max.   :23.9   Max.   :16.650
##
##     spin_dir        spin_rate          OnDL        trf_num_pitches
##  Min.   : 70.01   Min.   : 507.6   Min.   :0.0000   Min.   :  2.345
##  1st Qu.:161.79   1st Qu.:1668.6   1st Qu.:0.0000   1st Qu.: 29.283
##  Median :200.39   Median :1870.7   Median :0.0000   Median : 53.568
##  Mean   :192.05   Mean   :1850.2   Mean   :0.2371   Mean   : 55.531
##  3rd Qu.:217.19   3rd Qu.:2055.2   3rd Qu.:0.0000   3rd Qu.: 72.024
##  Max.   :325.10   Max.   :3000.0   Max.   :1.0000   Max.   :133.287
##
##    trf_num_AB      trf_num_AS      trf_num_CH       trf_num_CU
##  Min.   :1.225   Min.   :1.225   Min.   : 1.225   Min.   : 1.225
##  1st Qu.:1.225   1st Qu.:1.225   1st Qu.: 3.674   1st Qu.: 1.225
##  Median :1.225   Median :1.225   Median :10.654   Median : 4.637
##  Mean   :1.225   Mean   :1.225   Mean   :14.780   Mean   :11.646
##  3rd Qu.:1.225   3rd Qu.:1.225   3rd Qu.:22.506   3rd Qu.:19.326
##  Max.   :1.225   Max.   :2.345   Max.   :67.775   Max.   :68.129
##
##    trf_num_EP       trf_num_FA       trf_num_FC       trf_num_FF
##  Min.   : 1.225   Min.   : 1.225   Min.   : 1.225   Min.   : 1.225
##  1st Qu.: 1.225   1st Qu.: 1.225   1st Qu.: 1.225   1st Qu.:11.554
##  Median : 1.225   Median : 1.225   Median : 1.225   Median :26.486
##  Mean   : 1.287   Mean   : 1.329   Mean   : 7.061   Mean   :29.889
##  3rd Qu.: 1.225   3rd Qu.: 1.225   3rd Qu.: 5.050   3rd Qu.:44.805
##  Max.   :27.009   Max.   :16.778   Max.   :87.416   Max.   :98.598
##
```

```
##    trf_num_FO       trf_num_FS       trf_num_FT       trf_num_IN
##  Min.   : 1.225   Min.   : 1.225   Min.   : 1.225   Min.   : 1.225
##  1st Qu.: 1.225   1st Qu.: 1.225   1st Qu.: 1.225   1st Qu.: 1.225
##  Median : 1.225   Median : 1.225   Median : 6.124   Median : 3.674
##  Mean   : 1.233   Mean   : 2.949   Mean   :14.025   Mean   : 3.717
##  3rd Qu.: 1.225   3rd Qu.: 1.225   3rd Qu.:22.125   3rd Qu.: 5.788
##  Max.   :11.023   Max.   :57.180   Max.   :86.357   Max.   :13.019
##
##    trf_num_KC       trf_num_KN        trf_num_PO      trf_num_SC
##  Min.   : 1.225   Min.   :  1.225   Min.   :1.225   Min.   : 1.225
##  1st Qu.: 1.225   1st Qu.:  1.225   1st Qu.:1.225   1st Qu.: 1.225
##  Median : 1.225   Median :  1.225   Median :1.225   Median : 1.225
##  Mean   : 2.858   Mean   :  1.434   Mean   :1.714   Mean   : 1.249
##  3rd Qu.: 1.225   3rd Qu.:  1.225   3rd Qu.:2.345   3rd Qu.: 1.225
##  Max.   :65.920   Max.   :108.247   Max.   :6.745   Max.   :20.821
##
##    trf_num_SI       trf_num_SL       trf_num_UN
##  Min.   : 1.225   Min.   : 1.225   Min.   : 1.225
##  1st Qu.: 1.225   1st Qu.: 3.082   1st Qu.:11.726
##  Median : 1.225   Median :14.883   Median :20.821
##  Mean   : 9.778   Mean   :18.228   Mean   :23.235
##  3rd Qu.: 6.745   3rd Qu.:29.283   3rd Qu.:32.535
##  Max.   :92.030   Max.   :78.521   Max.   :79.231
##
```

Histogram of data

Continuous Variables with outliers

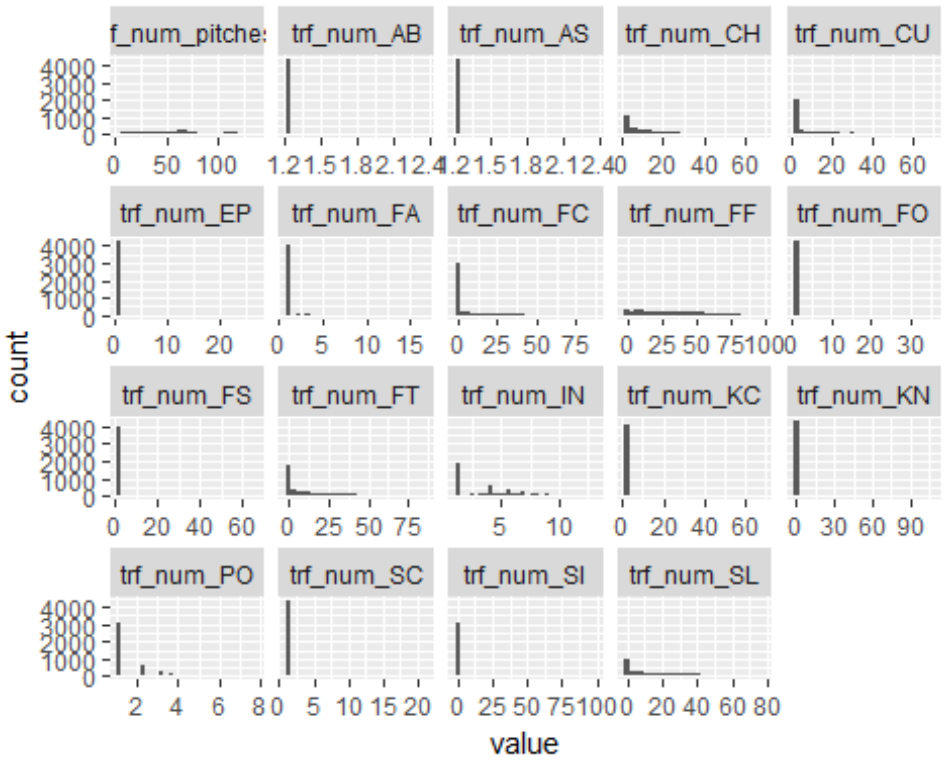
```
d <- melt(model_dataset[which(colnames(model_dataset) %in% original_var)]);

## No id variables; using all as measure variables

ggplot(d,aes(x = value)) + facet_wrap(~variable,scales = "free_x") +  geom_hi
stogram();

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



Count

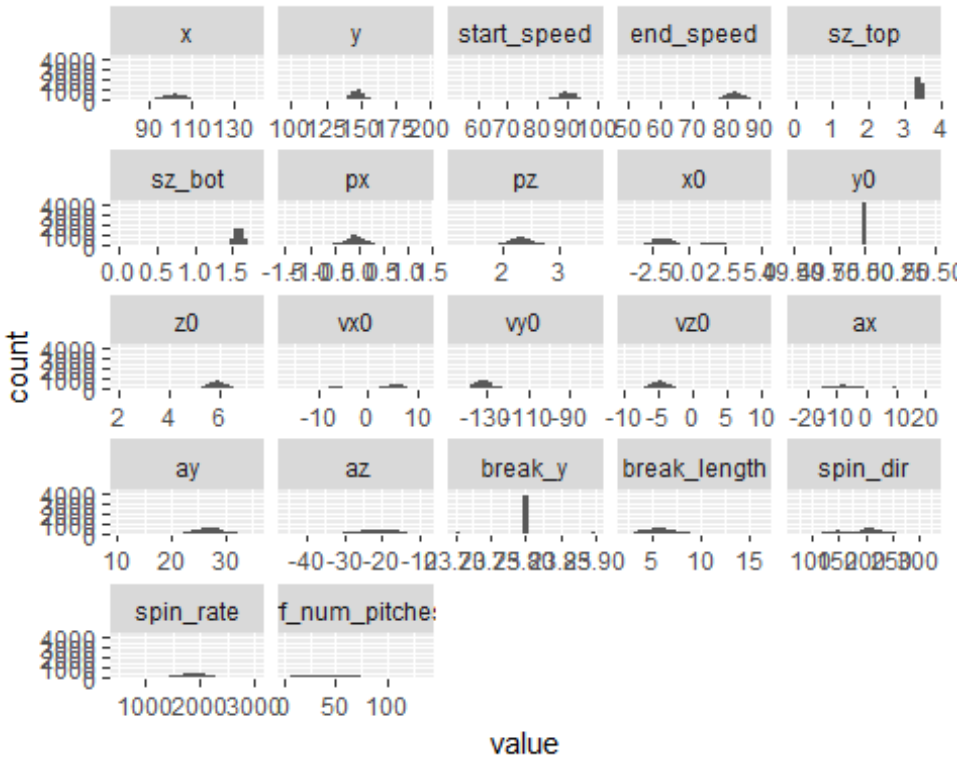
Variables with outliers

```
d <- melt(model_dataset[which(colnames(model_dataset) %in% count_var)]);

## No id variables; using all as measure variables

ggplot(d,aes(x = value)) + facet_wrap(~variable,scales = "free_x") +  geom_hi
stogram();

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



Continuous Variables without outliers

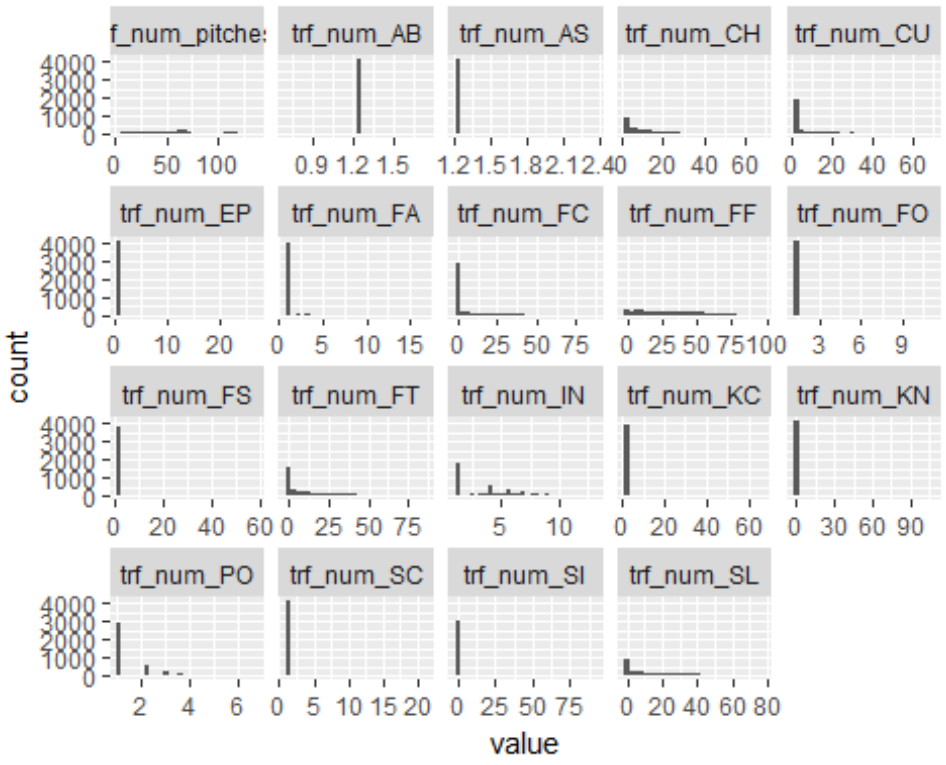
```
d <- melt(model_dataset_lessOutliers[which(colnames(model_dataset_lessOutliers) %in% original_var)]);

## No id variables; using all as measure variables

ggplot(d,aes(x = value)) + facet_wrap(~variable,scales = "free_x") +  geom_histogram();

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



Count

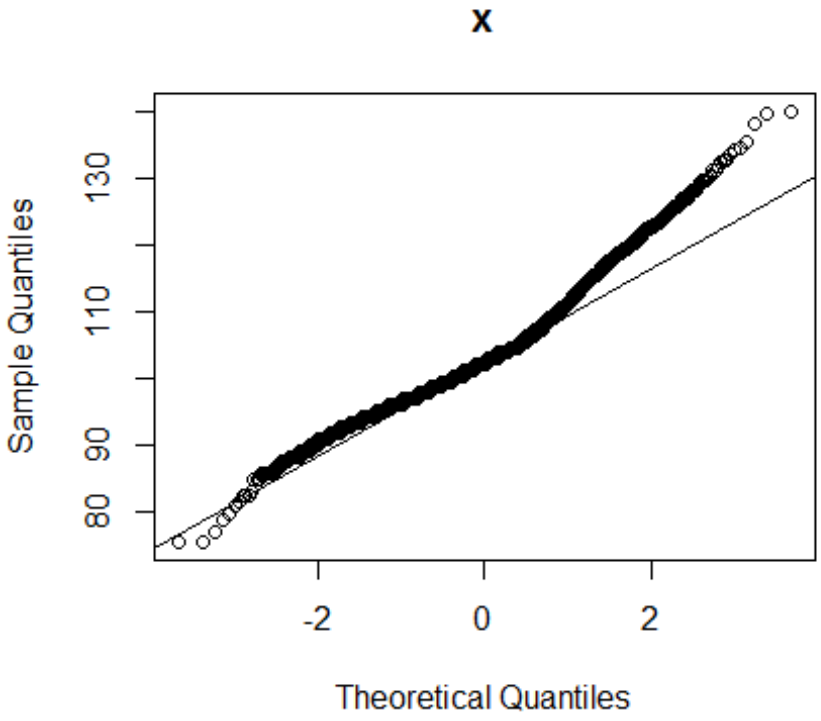
Variables without outlisers

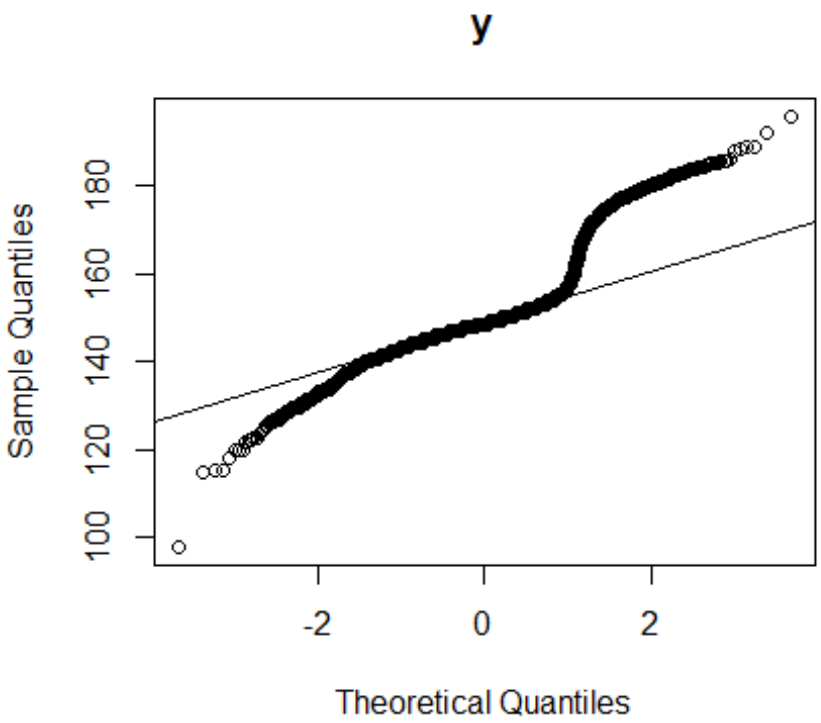
```
d <- melt(model_dataset_lessOutliers[which(colnames(model_dataset_lessOutlier
s) %in% count_var)]);

## No id variables; using all as measure variables

ggplot(d,aes(x = value)) + facet_wrap(~variable,scales = "free_x") +  geom_hi
stogram();

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

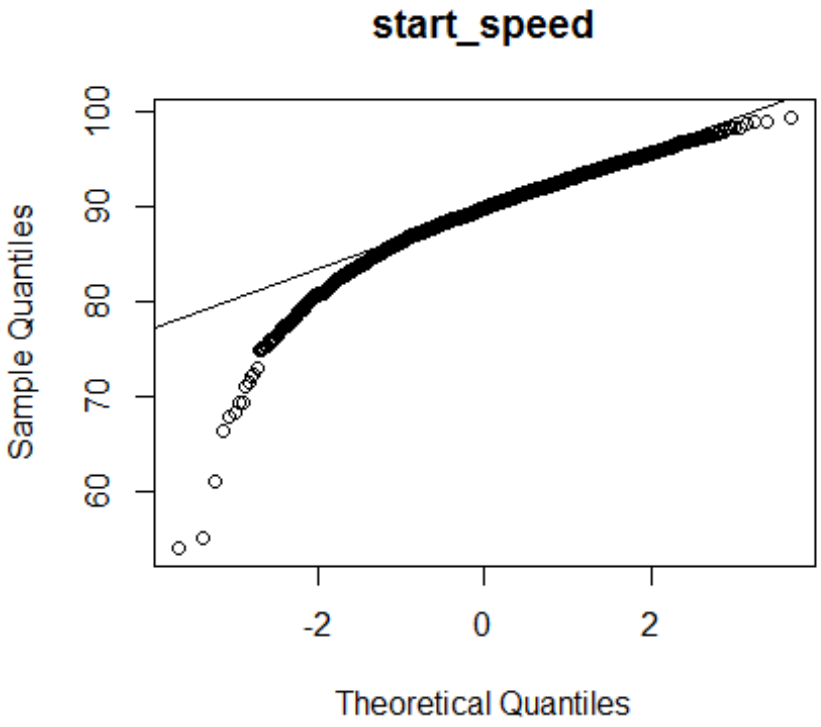


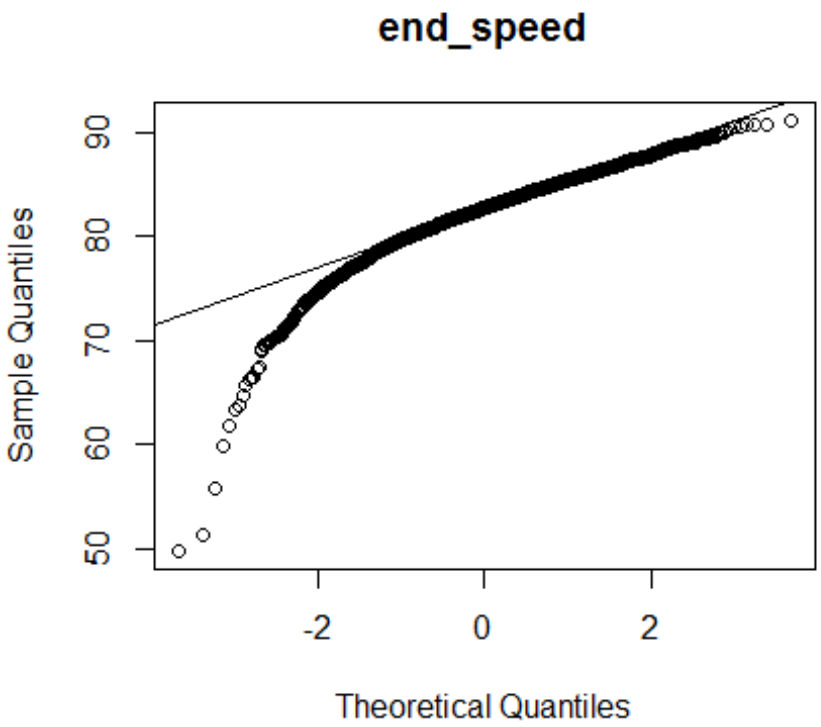
Check normality using QQ plot without outliers

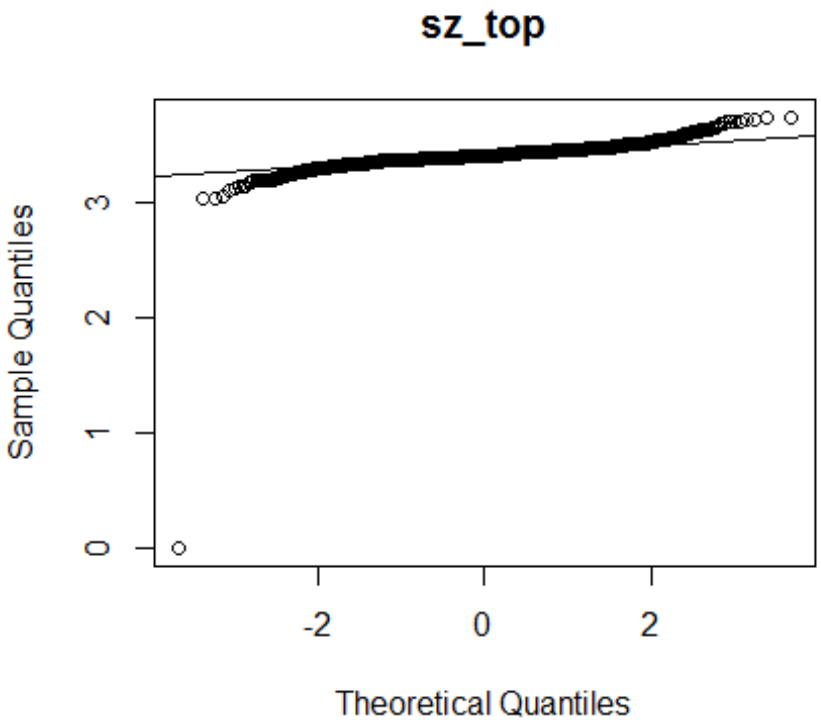
```
par(mar=c(4,4,4,4))

for (i in 2:(ncol(model_dataset_lessOutliers)-1)){
  tmp <- model_dataset_lessOutliers[, i];
  qqnorm(tmp, main = colnames(model_dataset_lessOutliers[i]));
  qqline(tmp);
}
```


x
Sample Quantiles
80
90
110
130
-2
0
2
Theoretical Quantiles

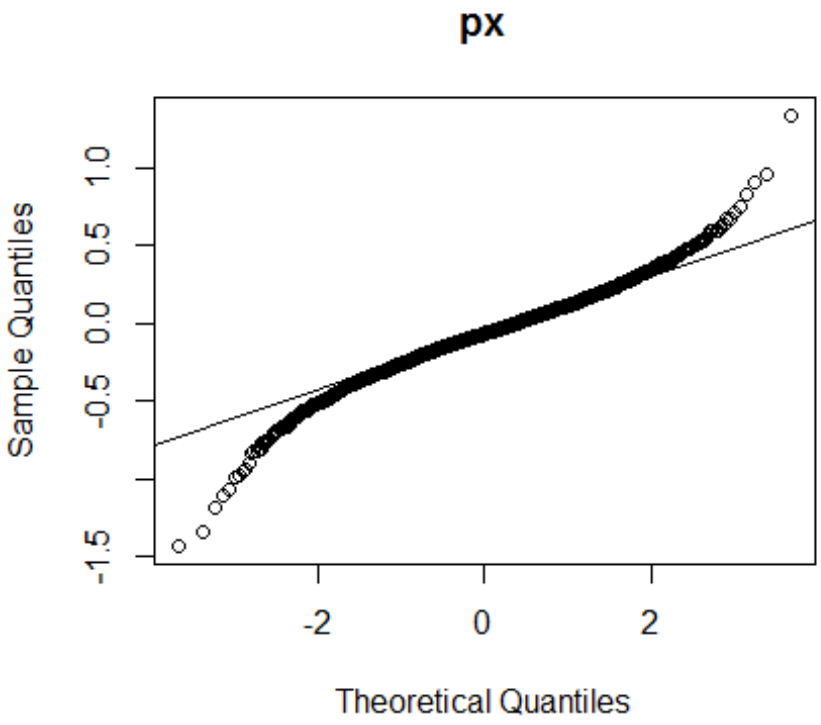

y
Sample Quantiles
100
120
140
160
180
-2
0
2
Theoretical Quantiles

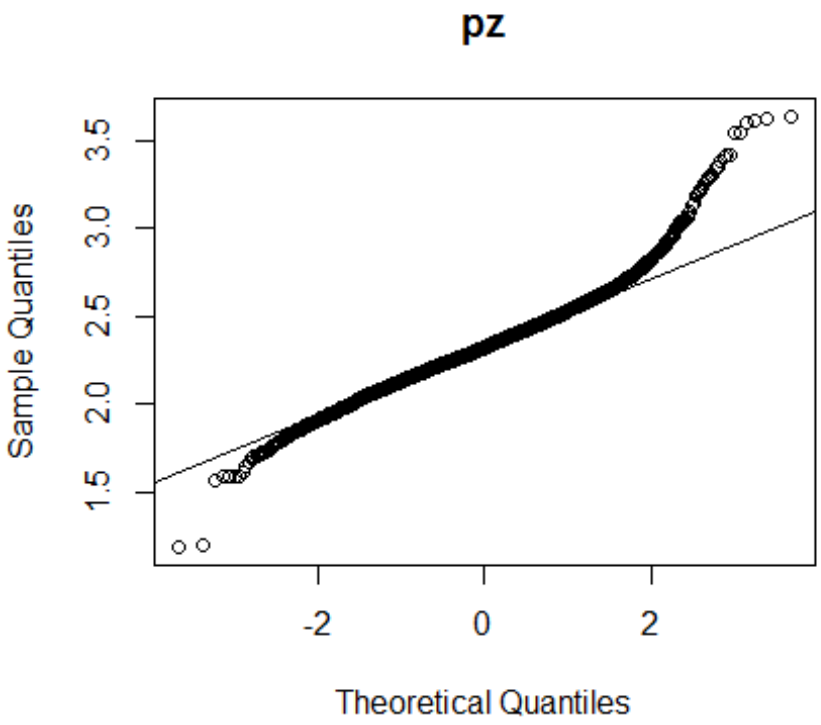

start_speed
Sample Quantiles
100
90
80
70
60
-2
0
2
Theoretical Quantiles

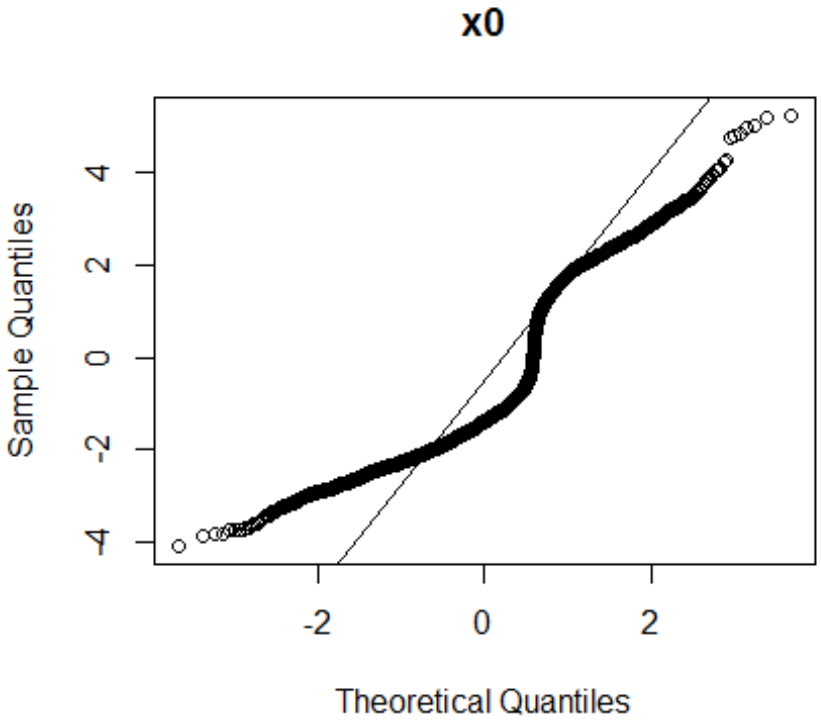

end_speed
Sample Quantiles
90
80
70
60
50
-2
0
2
Theoretical Quantiles

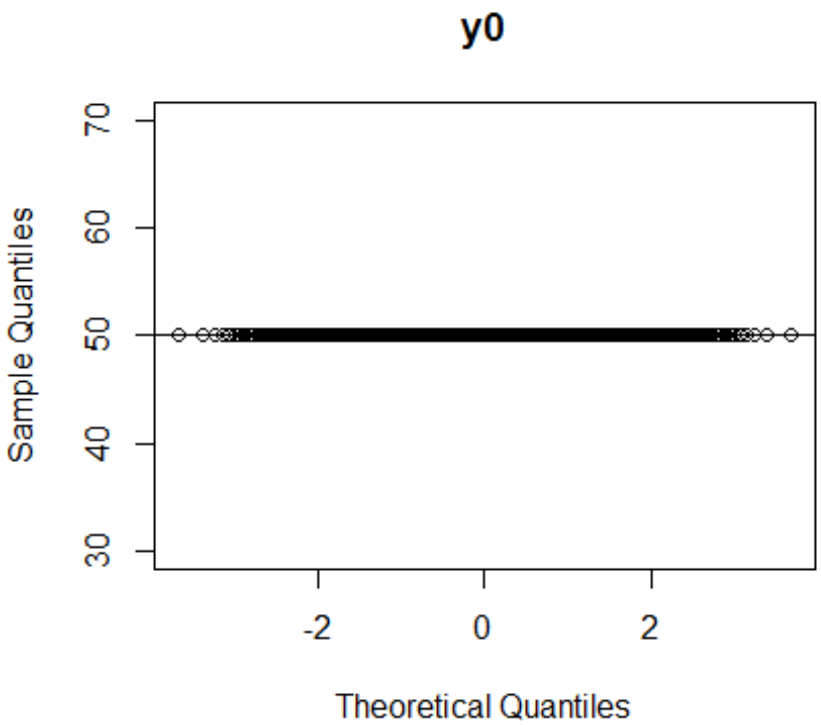

sz_top
Sample Quantiles
0
1
2
3
-2
0
2
Theoretical Quantiles

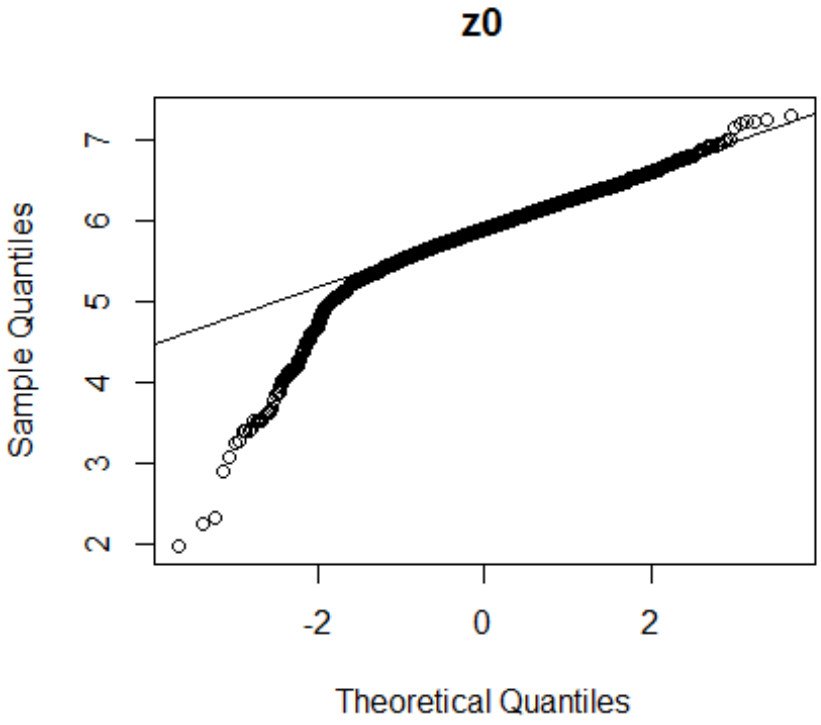

sz_bot
Sample Quantiles
0.0
0.5
1.0
1.5
-2
0
2
Theoretical Quantiles

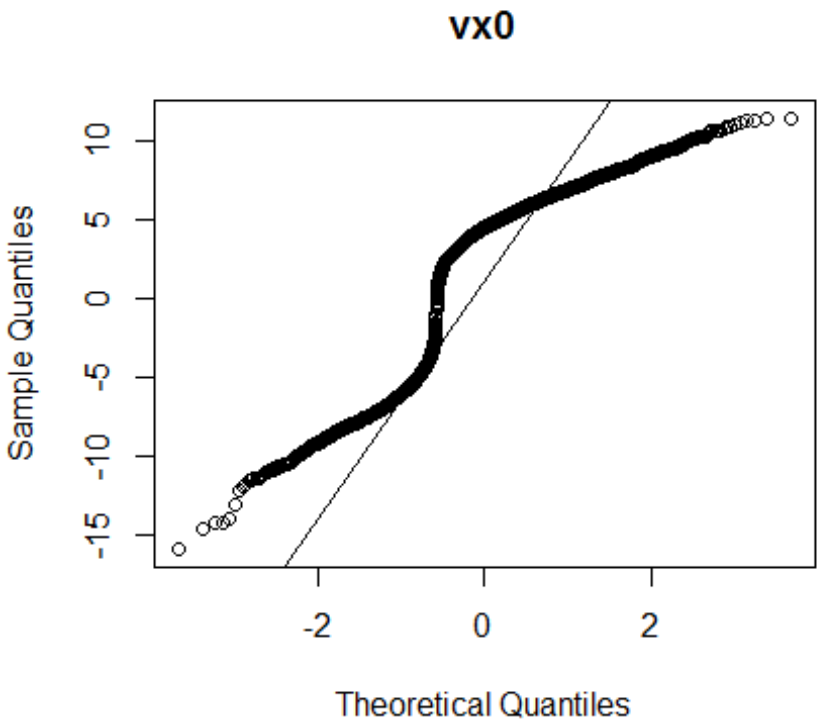

px
Sample Quantiles
-1.5
-0.5
0.0
0.5
1.0
-2
0
2
Theoretical Quantiles

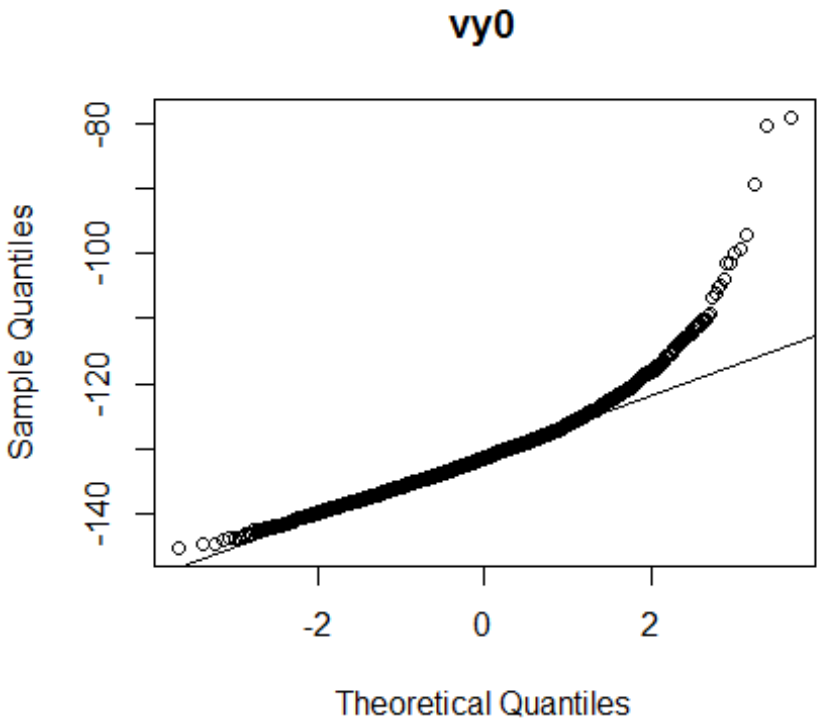

pz
Sample Quantiles
1.5
2.0
2.5
3.0
3.5
-2
0
2
Theoretical Quantiles

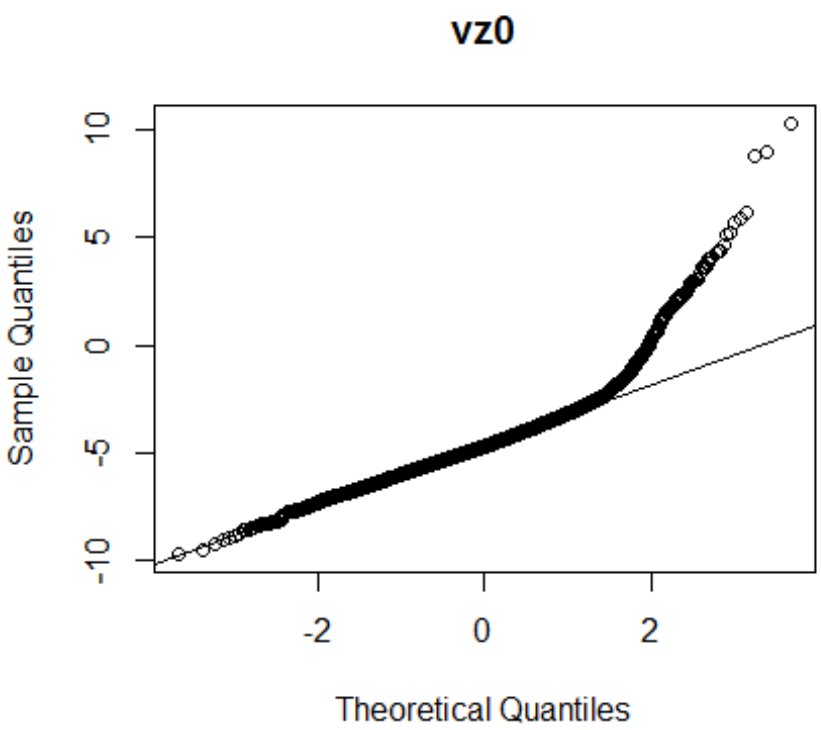

x0
Sample Quantiles
4
2
0
-2
-4
-2
0
2
Theoretical Quantiles

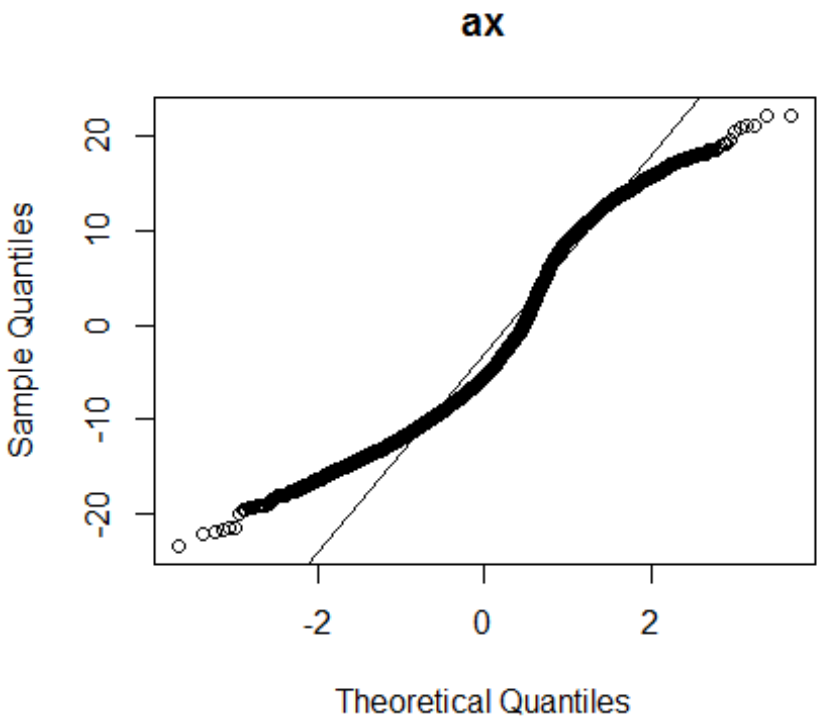

y0
Sample Quantiles
70
60
50
40
30
-2
0
2
Theoretical Quantiles

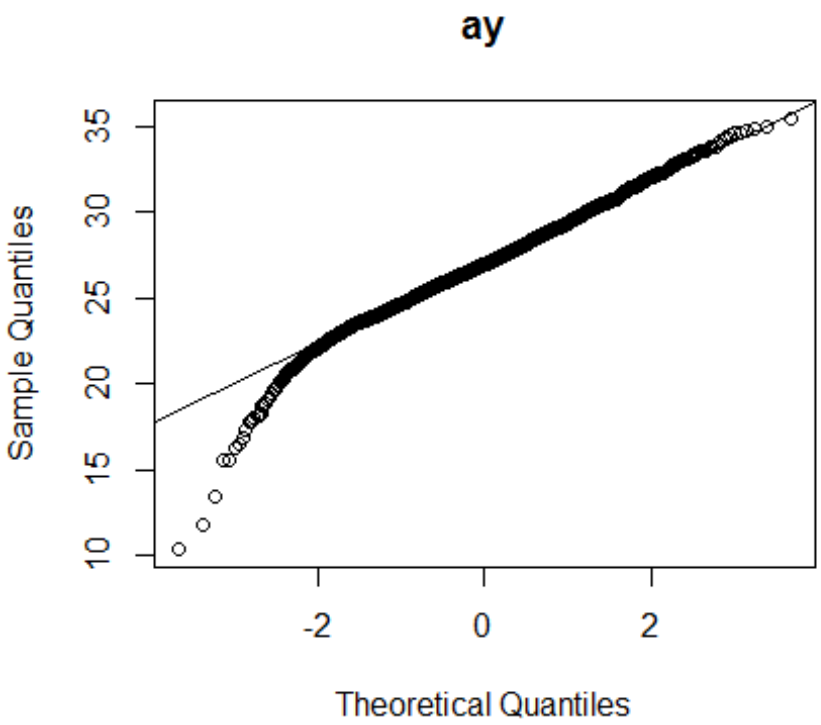

z0
Sample Quantiles
2
3
4
5
6
7
-2
0
2
Theoretical Quantiles

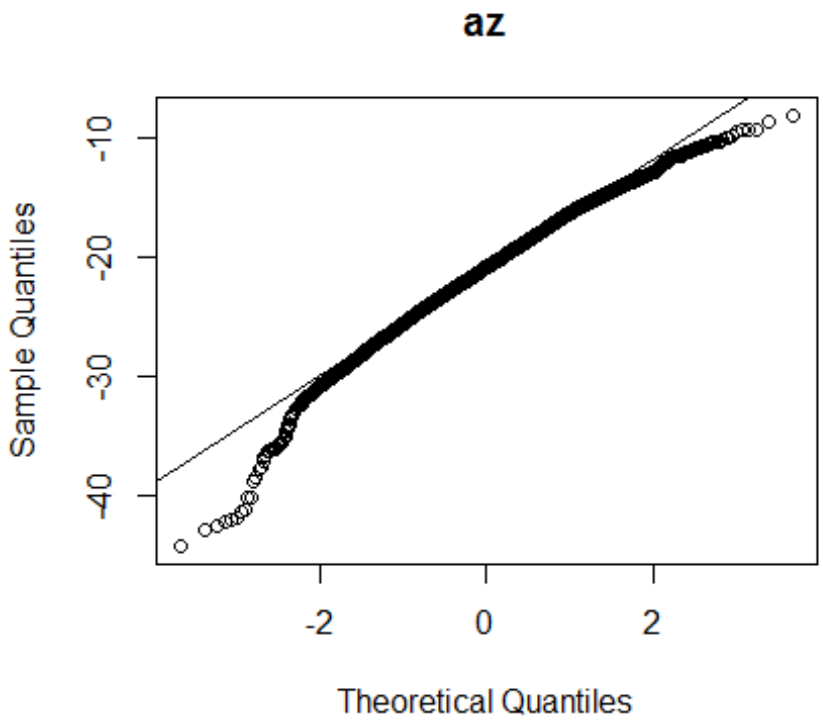

vx0
Sample Quantiles
-15
-10
-5
0
5
10
-2
0
2
Theoretical Quantiles

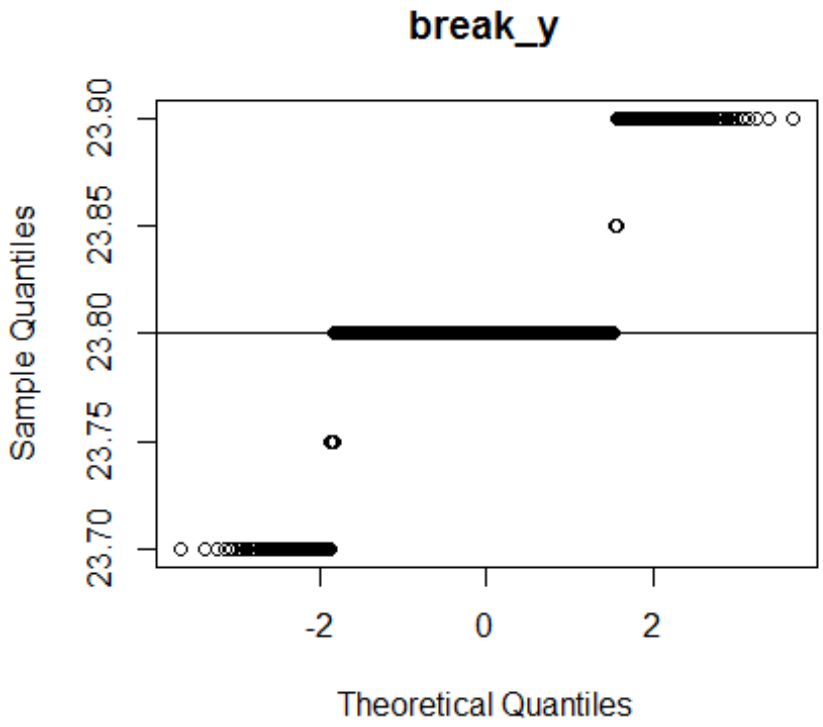

vy0
Sample Quantiles
-80
-100
-120
-140
-2
0
2
Theoretical Quantiles

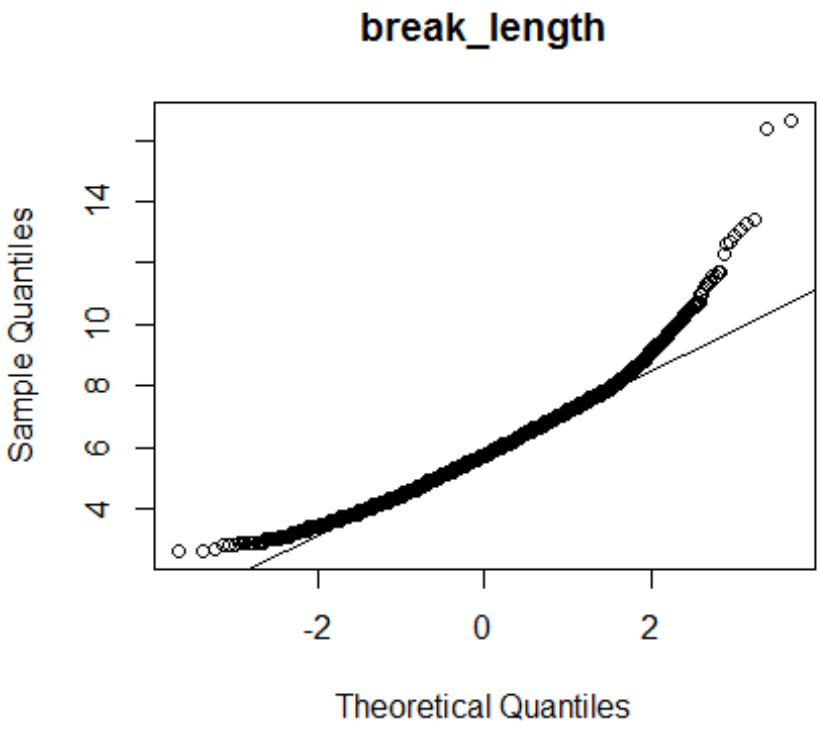

vz0
Sample Quantiles
10
5
0
-5
-10
-2
0
2
Theoretical Quantiles

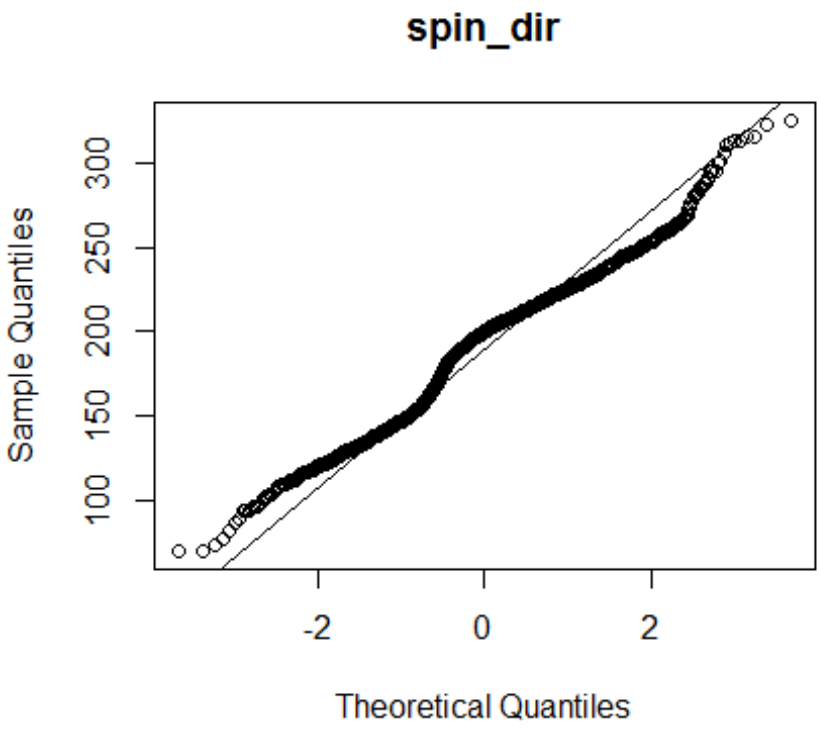

ax
Sample Quantiles
20
10
0
-10
-20
-2
0
2
Theoretical Quantiles

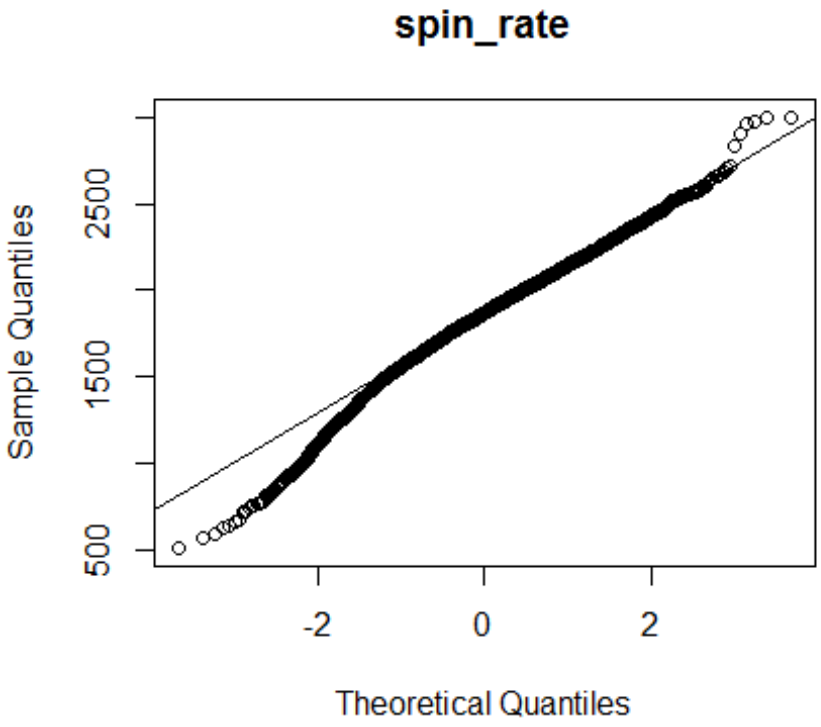

ay
Sample Quantiles
35
30
25
20
15
10
-2
0
2
Theoretical Quantiles

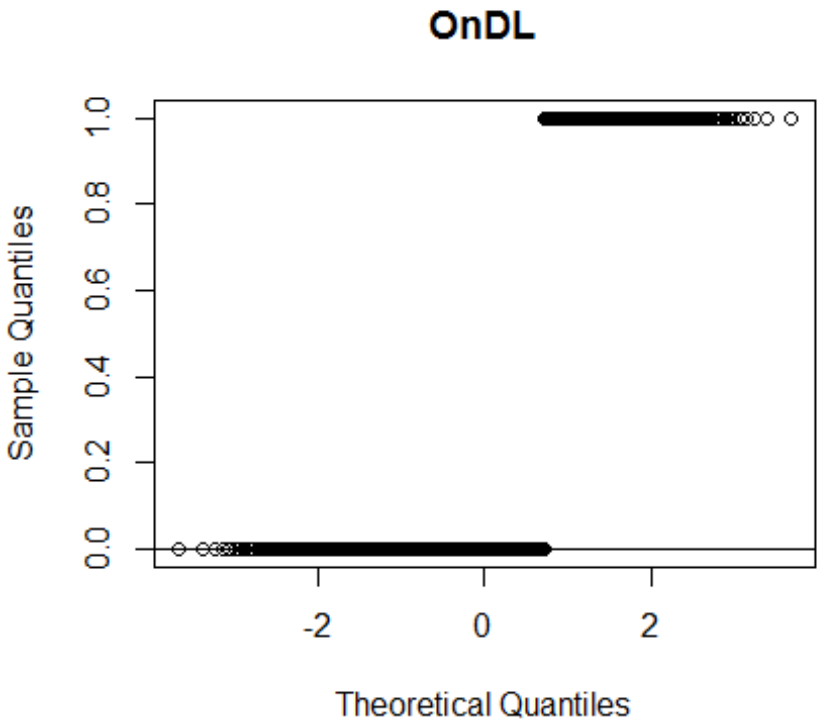

az
Sample Quantiles
-10
-20
-30
-40
-2
0
2
Theoretical Quantiles

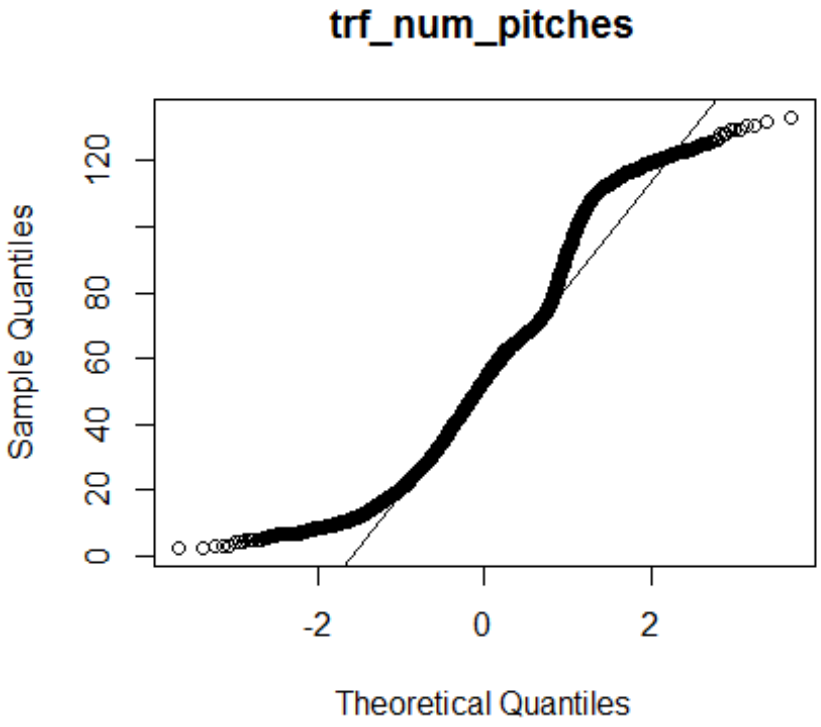

break_y
Sample Quantiles
23.90
23.85
23.80
23.75
23.70
-2
0
2
Theoretical Quantiles

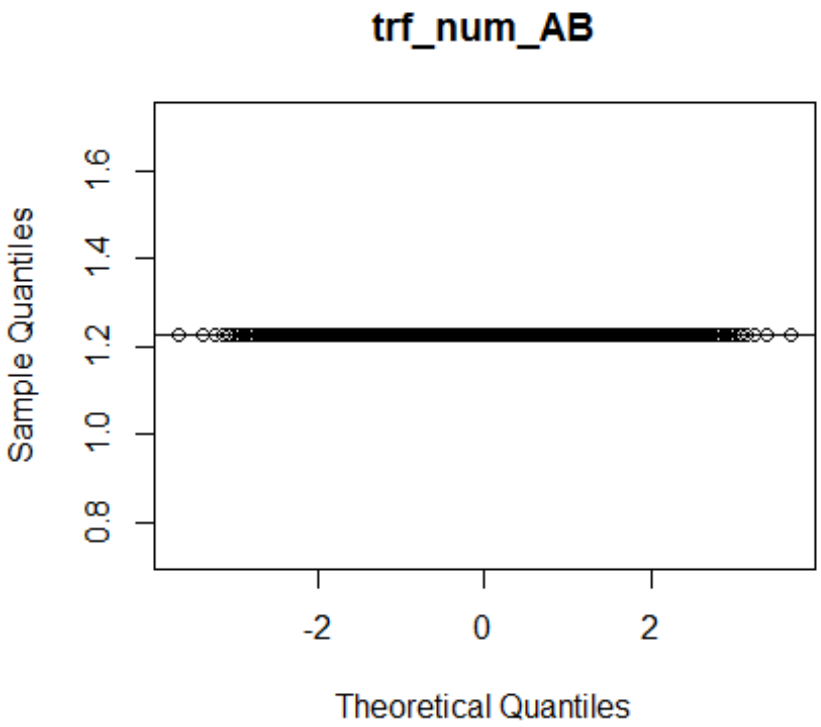

break_length
Sample Quantiles
4
6
8
10
14
-2
0
2
Theoretical Quantiles

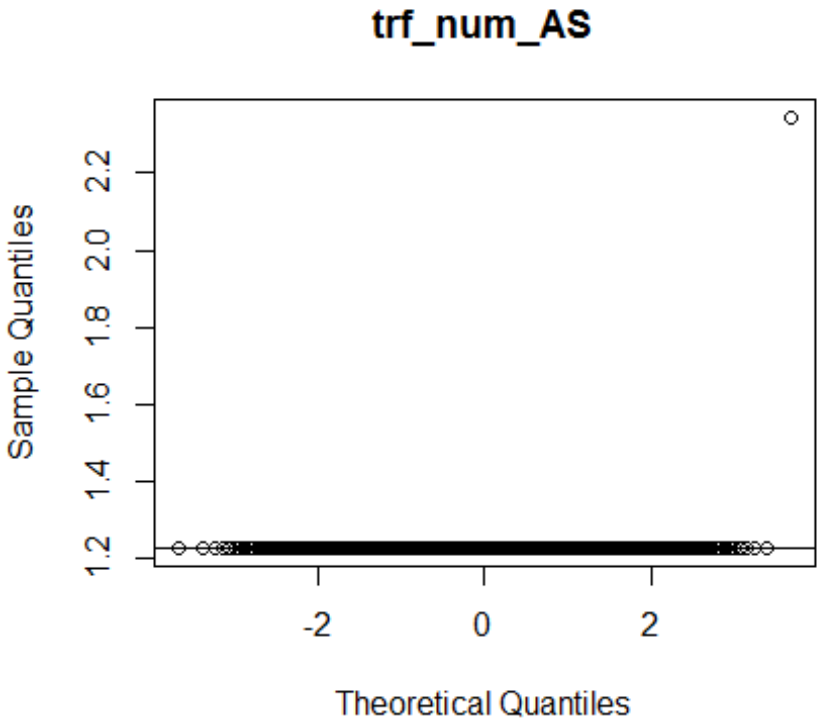

spin_dir
Sample Quantiles
100
150
200
250
300
-2
0
2
Theoretical Quantiles

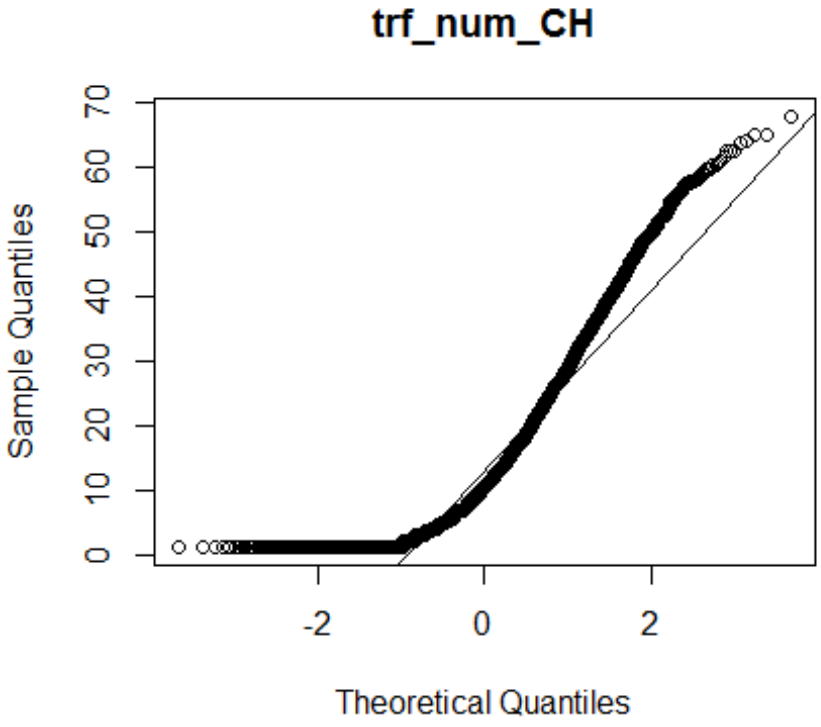

spin_rate
Sample Quantiles
500
1500
2500
-2
0
2
Theoretical Quantiles

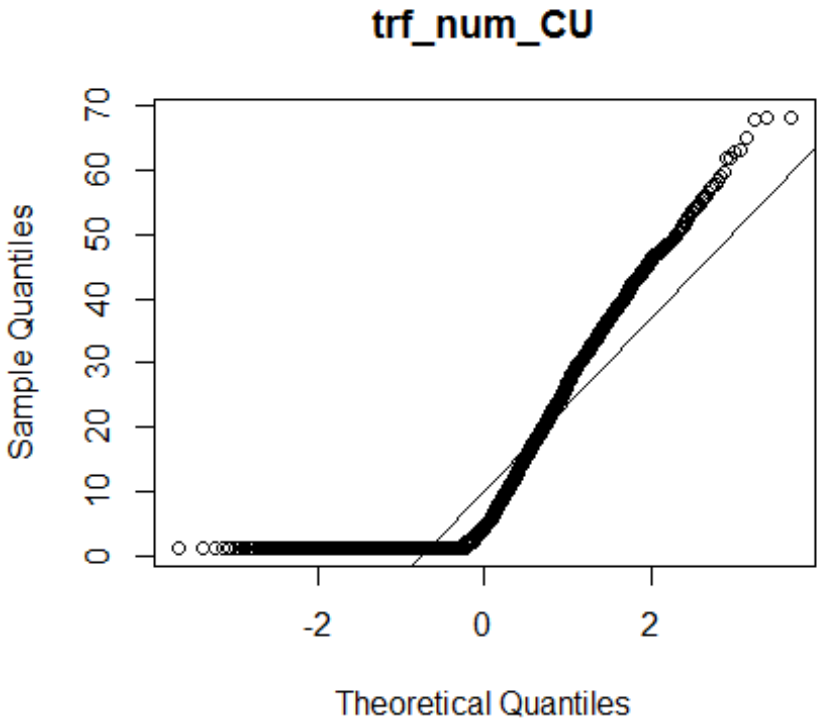

OnDL
Sample Quantiles
0.0
0.2
0.4
0.6
0.8
1.0
-2
0
2
Theoretical Quantiles

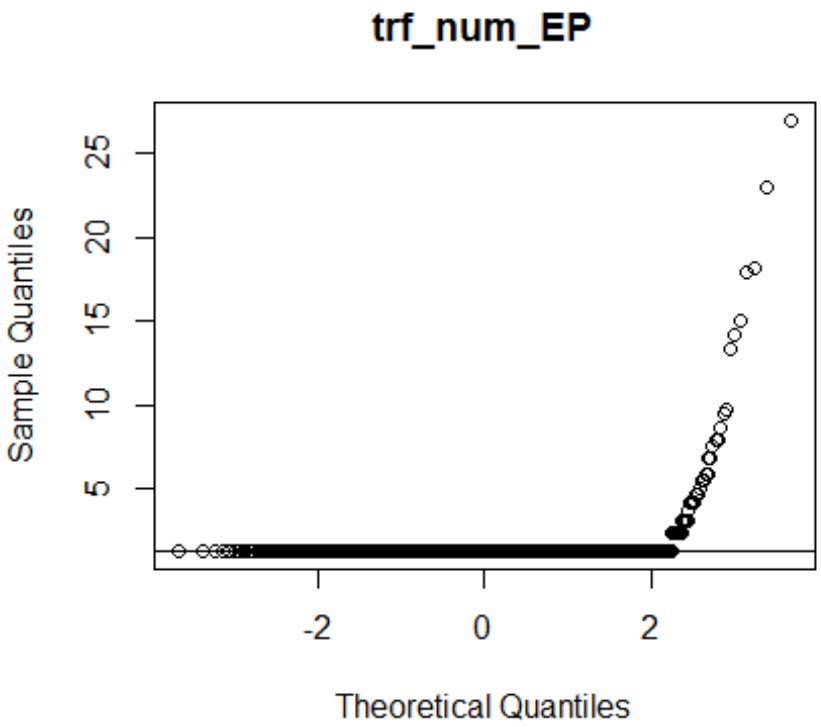

trf_num_pitches
Sample Quantiles
0
20
40
60
80
120
-2
0
2
Theoretical Quantiles

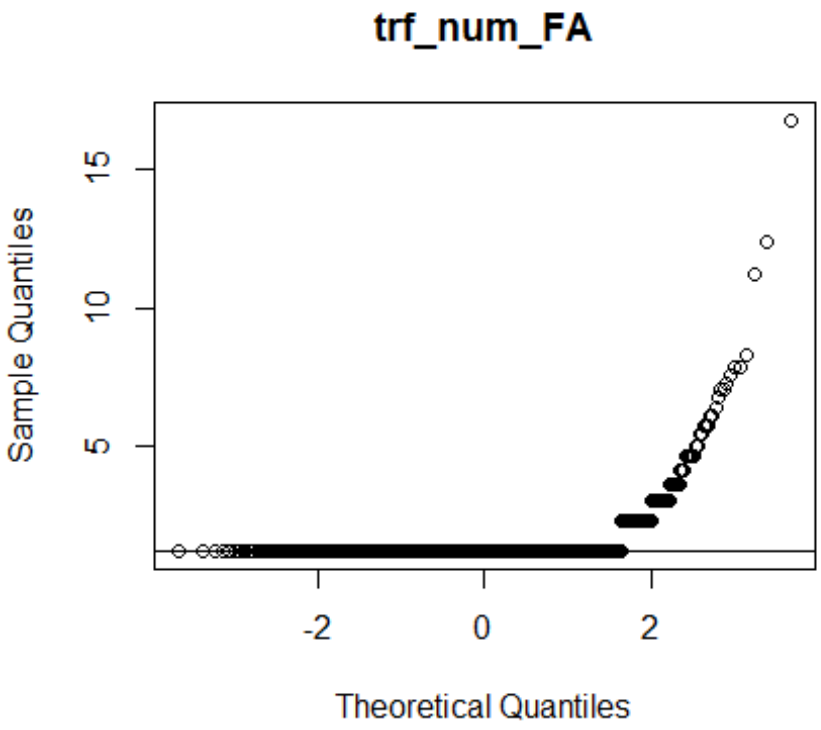

trf_num_AB
Sample Quantiles
0.8
1.0
1.2
1.4
1.6
-2
0
2
Theoretical Quantiles

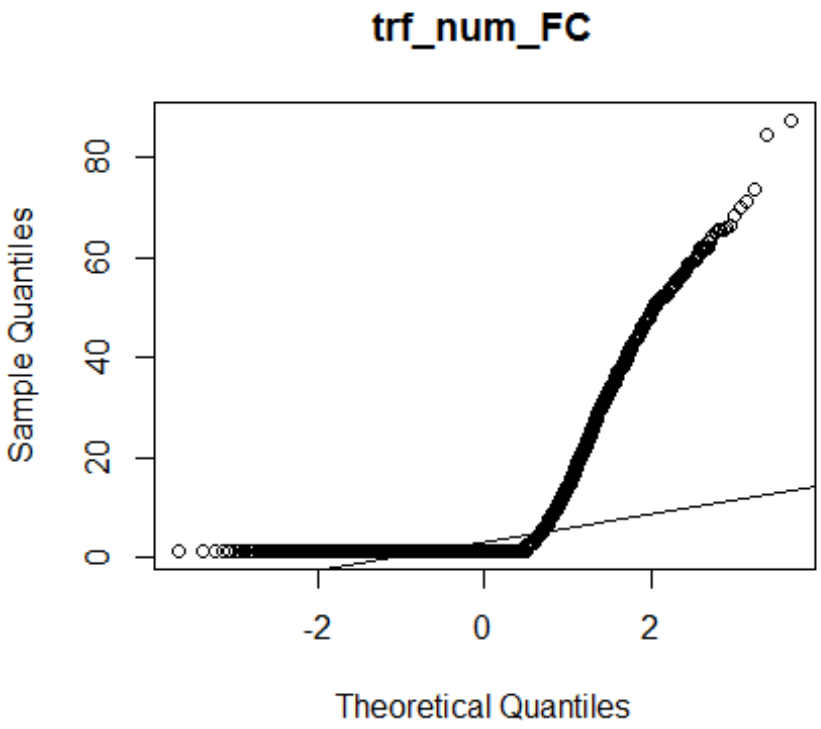

trf_num_AS
Sample Quantiles
1.2
1.4
1.6
1.8
2.0
2.2
-2
0
2
Theoretical Quantiles

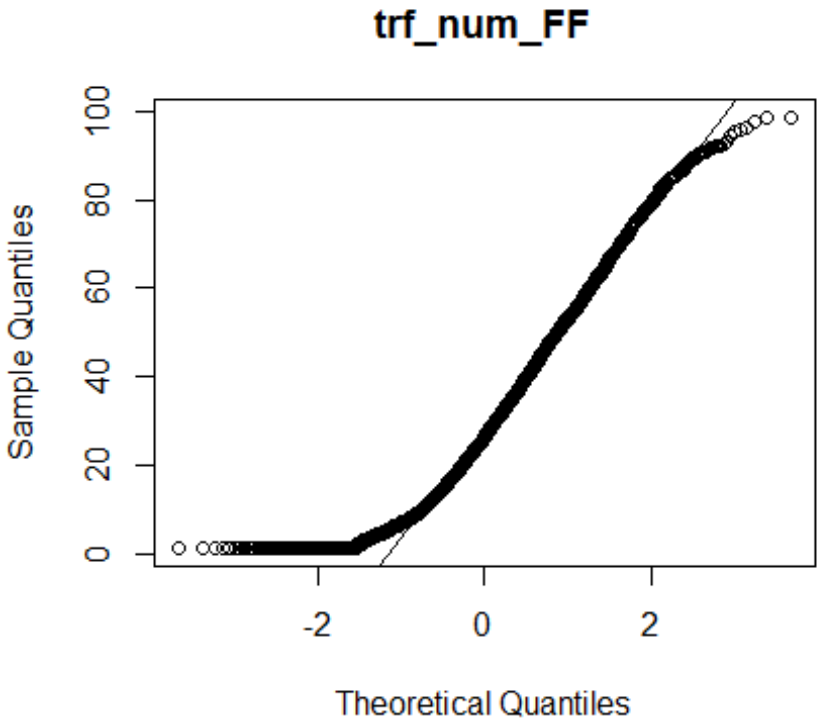

trf_num_CH
Sample Quantiles
0
10
20
30
40
50
60
70
-2
0
2
Theoretical Quantiles

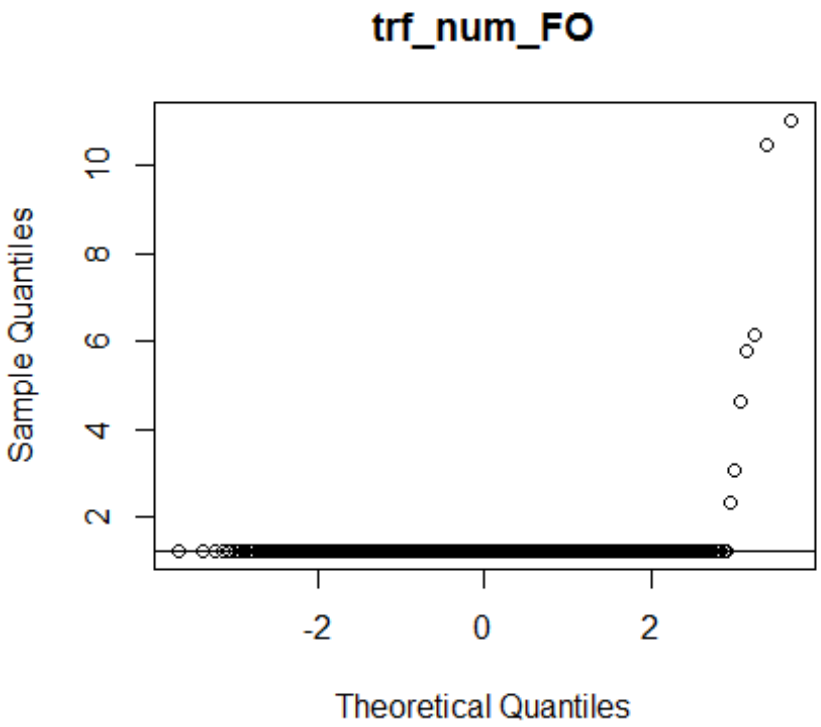

trf_num_CU
Sample Quantiles
0
10
20
30
40
50
60
70
-2
0
2
Theoretical Quantiles

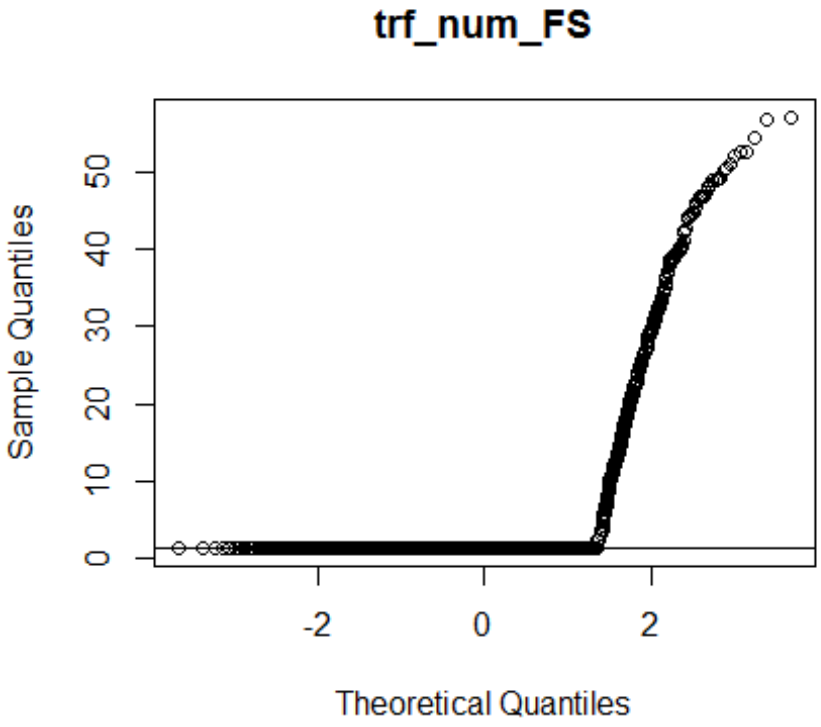

trf_num_EP
Sample Quantiles
5
10
15
20
25
-2
0
2
Theoretical Quantiles

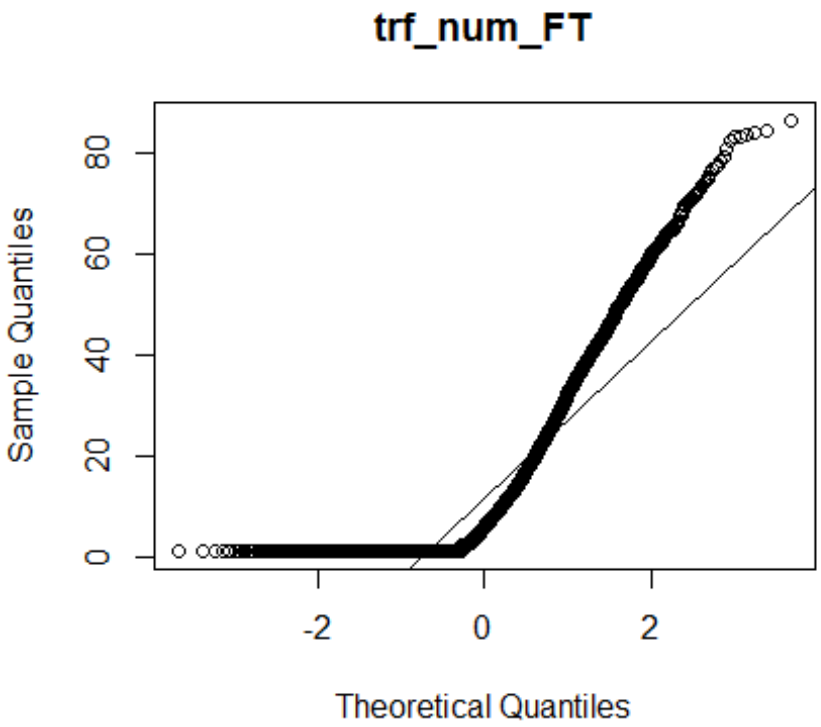

trf_num_FA
Sample Quantiles
5
10
15
-2
0
2
Theoretical Quantiles

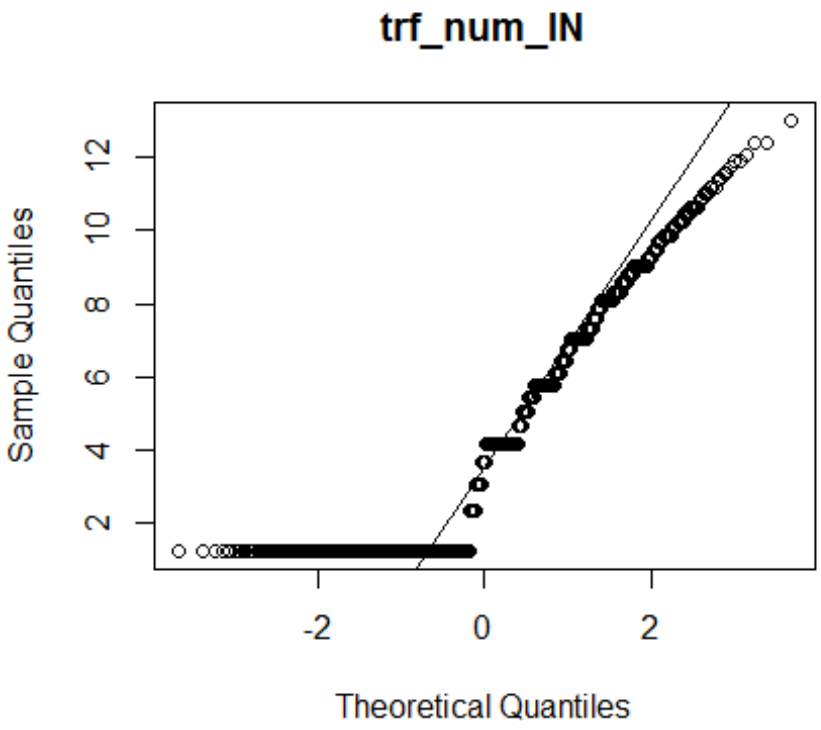

trf_num_FC
Sample Quantiles
0
20
40
60
80
-2
0
2
Theoretical Quantiles

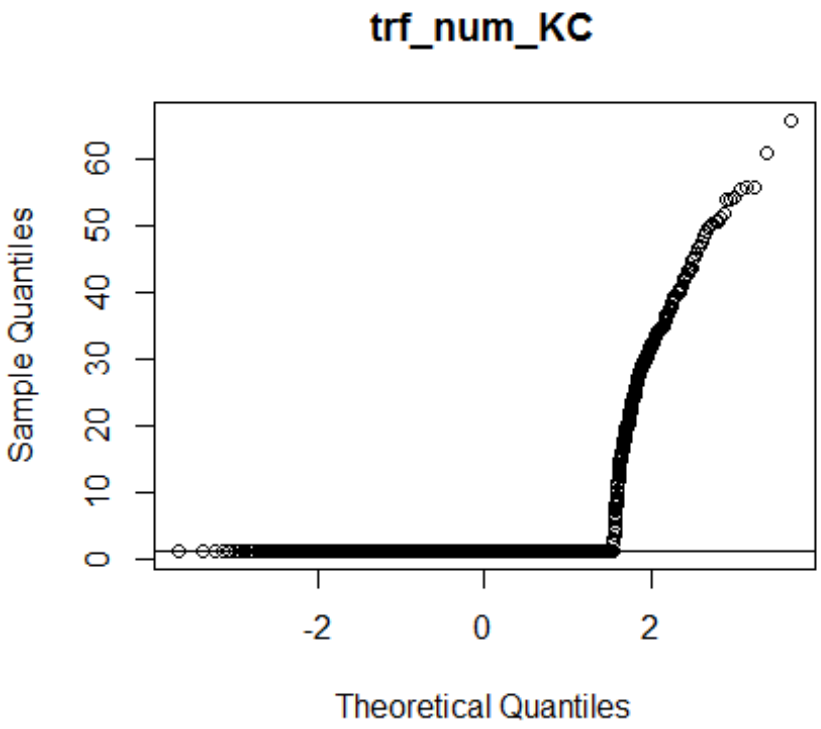

trf_num_FF
Sample Quantiles
0
20
40
60
80
100
-2
0
2
Theoretical Quantiles

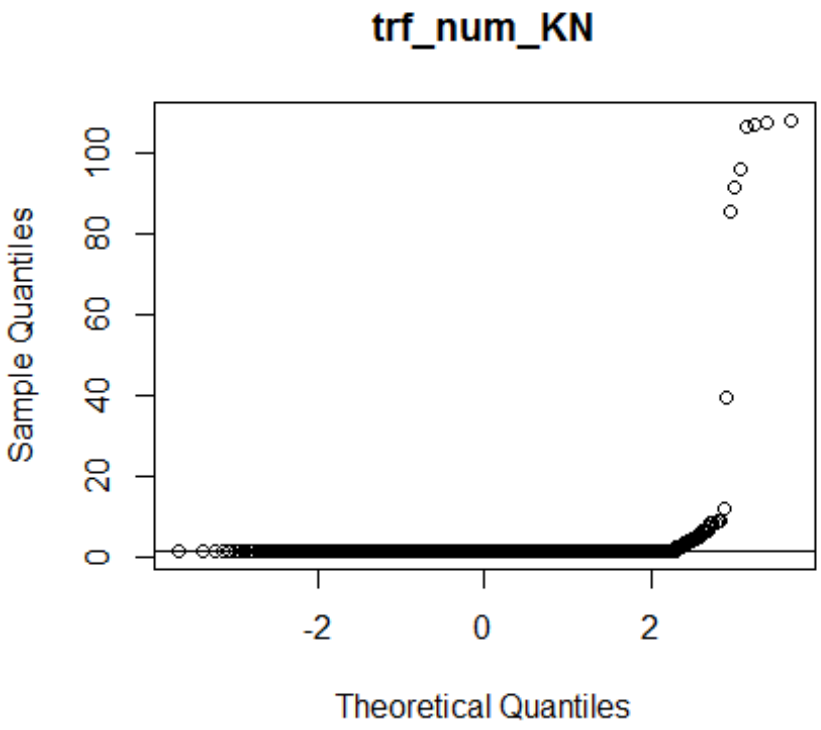

trf_num_FO
Sample Quantiles
2
4
6
8
10
-2
0
2
Theoretical Quantiles

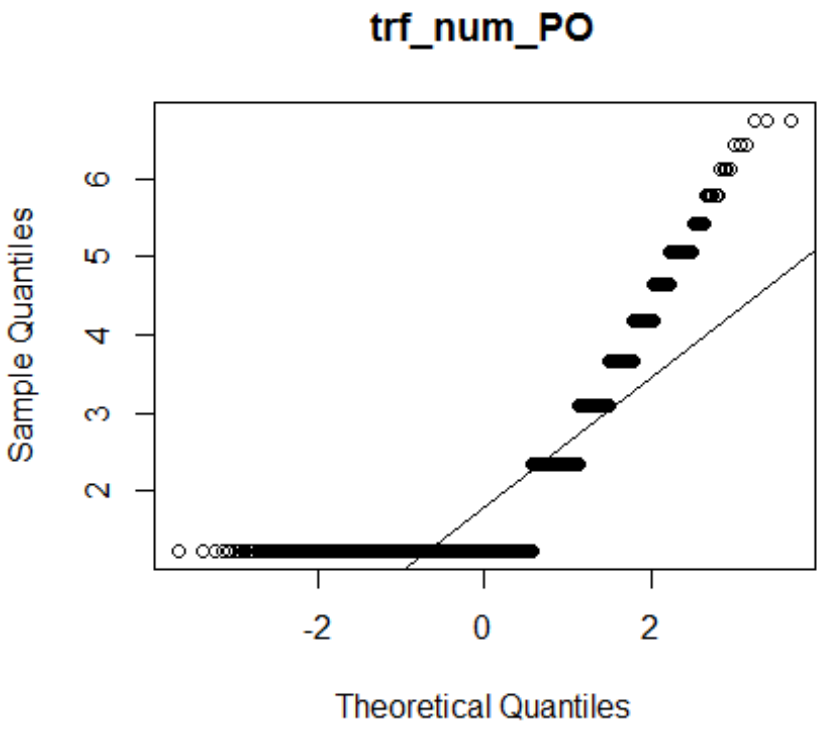

trf_num_FS
Sample Quantiles
0
10
20
30
40
50
-2
0
2
Theoretical Quantiles

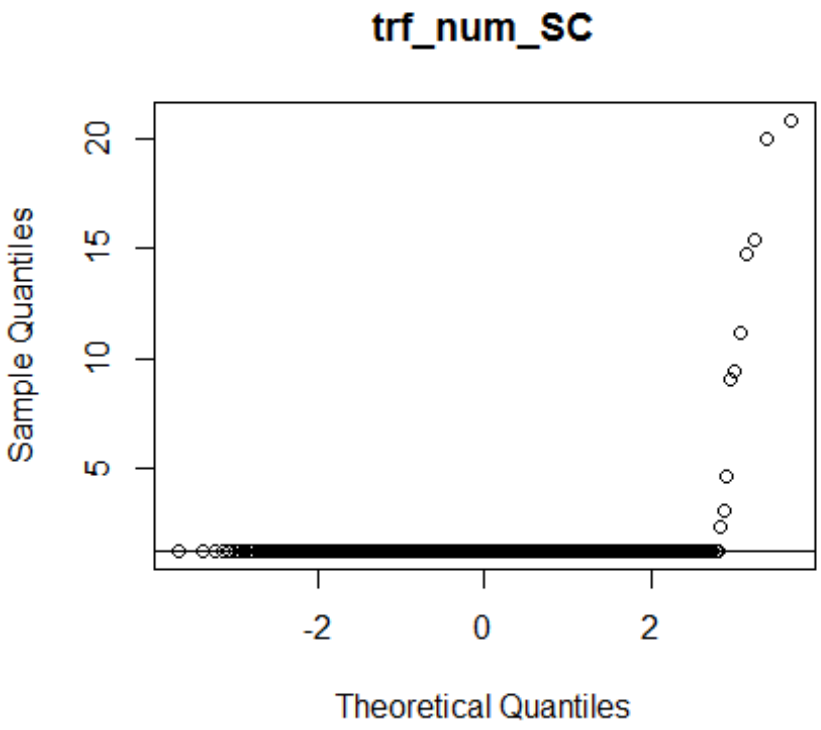

trf_num_FT
Sample Quantiles
0
20
40
60
80
-2
0
2
Theoretical Quantiles

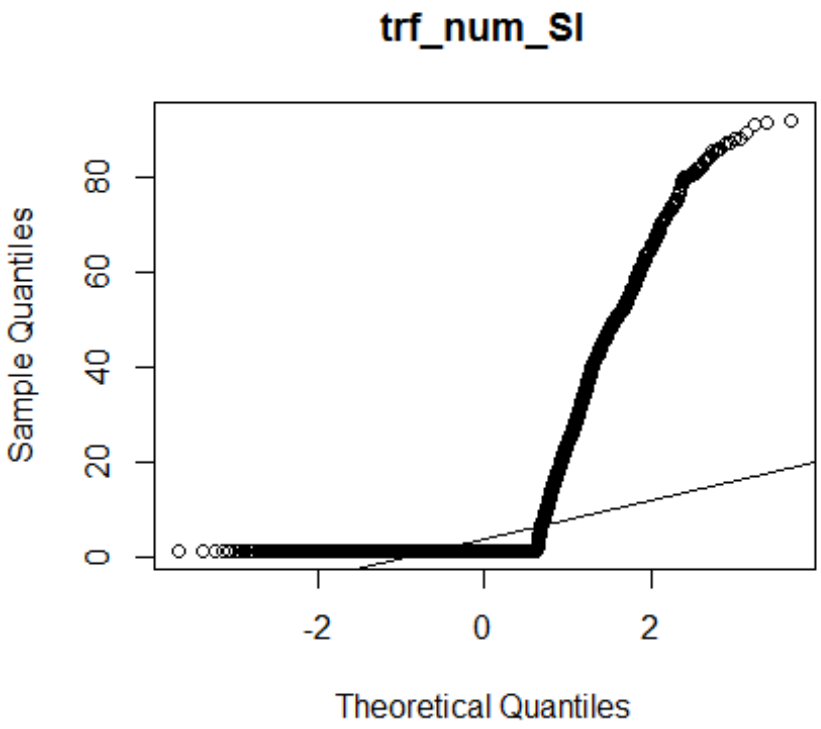

trf_num_IN
Sample Quantiles
2
4
6
8
10
12
-2
0
2
Theoretical Quantiles

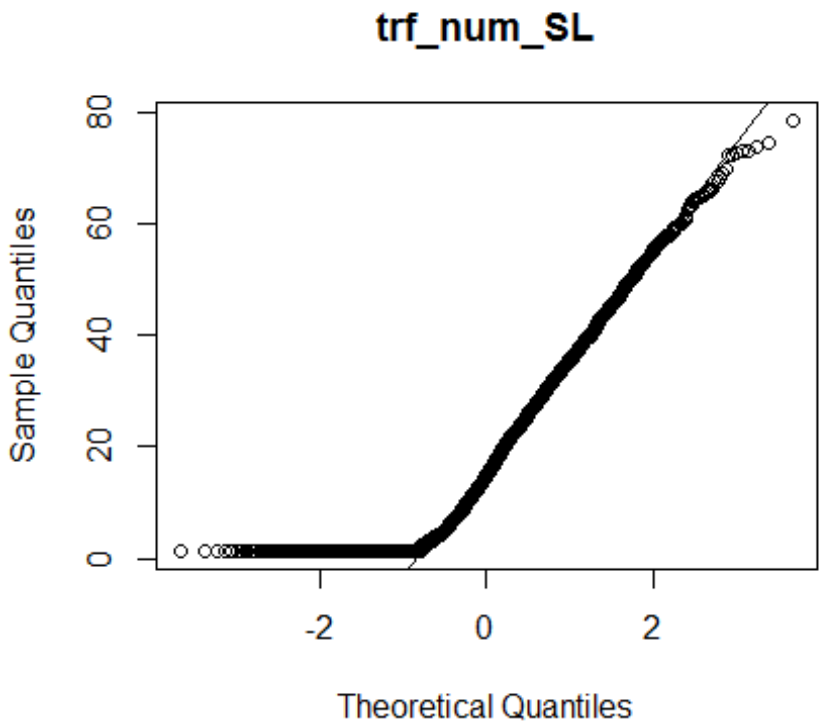

trf_num_KC
Sample Quantiles
0
10
20
30
40
50
60
-2
0
2
Theoretical Quantiles


trf_num_KN
Sample Quantiles
0
20
40
60
80
100
-2
0
2
Theoretical Quantiles


trf_num_PO
Sample Quantiles
2
3
4
5
6
-2
0
2
Theoretical Quantiles


trf_num_SC
Sample Quantiles
5
10
15
20
-2
0
2
Theoretical Quantiles

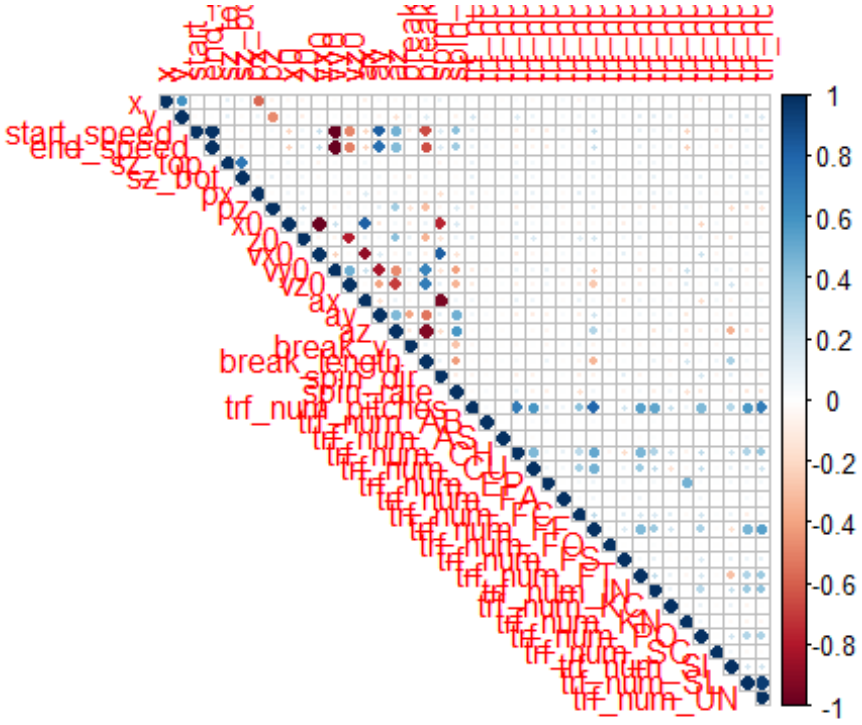

trf_num_SI
Sample Quantiles
0
20
40
60
80
-2
0
2
Theoretical Quantiles



Display correlation

All variables

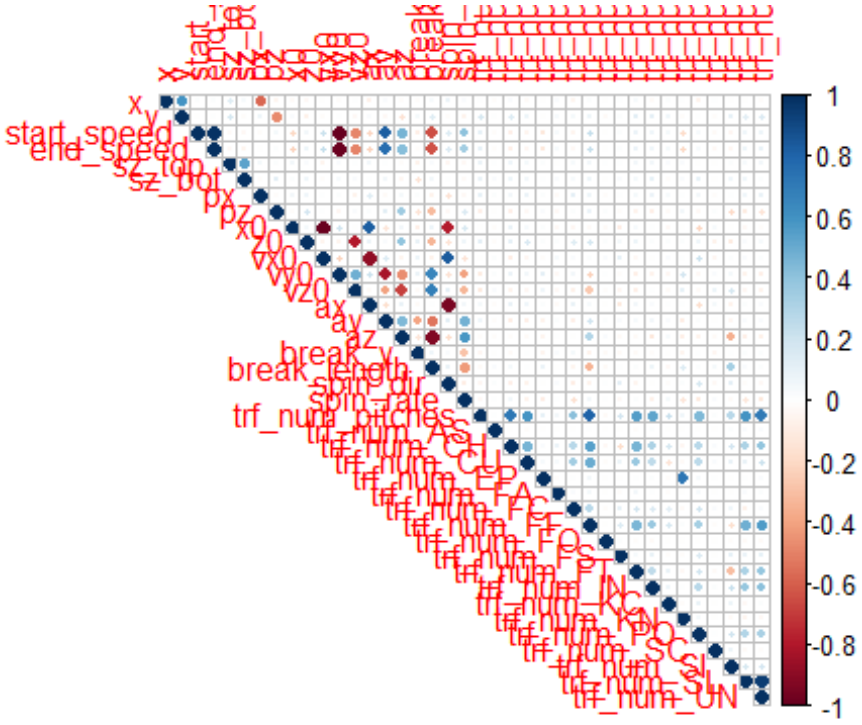
```
numeric_dataset <- model_dataset[sapply(model_dataset, is.numeric)];

#ignore column y0 since there is 0 variance
numeric_dataset <- numeric_dataset[ , !(names(numeric_dataset) %in% c("y0", "
OnDL"))];

#numeric_dataset <- numeric_dataset[1:(ncol(numeric_dataset))];
m <- cor(numeric_dataset);
corrplot::corrplot(m, type="upper");
```




```
#corrplot::corrplot.mixed(m);
```

All variables without outliers

```
numeric_dataset_lessOutliers <- model_dataset_lessOutliers[sapply(model_datas
et_lessOutliers, is.numeric)];

#ignore column y0 since there is 0 variance
numeric_dataset_lessOutliers <- numeric_dataset_lessOutliers[ , !(names(numer
ic_dataset_lessOutliers) %in% c("y0", "trf_num_AB", "OnDL"))];

#numeric_dataset <- numeric_dataset[1:(ncol(numeric_dataset))];
m_lessOutliers <- cor(numeric_dataset_lessOutliers);
corrplot::corrplot(m_lessOutliers, type="upper");
```




```
#corrplot::corrplot.mixed(m_lessOutliers);
```

Model Building with all data

Model 1 All variables

Create training and testing set using 75% training and 25% testing

```
set.seed(123)

train <- createDataPartition(model_dataset$OnDL, p=0.75, list=FALSE);

training <- model_dataset[train,];
write.csv(training, "training.csv");

testing <- model_dataset[-train,];


threshold <- 0.4;
```

Construct Model

```
selected_variables <- dependent_var;

selected_i <- which(colnames(training) %in% selected_variables);
```

```
formula_text <- paste(response_var, "~",
                      paste(names(training)[selected_i], collapse="+"));
formula <- as.formula(formula_text);

mod_1 = glm(formula = formula , family=binomial(logit), data=training);
```

Summary

The summary shows that variables which have some significance to the outcomes are: end_speed, sz_bot, pz, z0, vz0, break_y, break_length, trf_num_pitches, trf_num_CH, trf_num_FT, trf_num_SI, trf_num_UN

```
summary(mod_1);
```

```
##
## Call:
## glm(formula = formula, family = binomial(logit), data = training)
##
## Deviance Residuals:
##     Min       1Q   Median       3Q      Max
## -1.6157  -0.7642  -0.5675   0.8835   2.4404
##
## Coefficients: (1 not defined because of singularities)
##                   Estimate Std. Error z value Pr(>|z|)
## (Intercept)      4.791e+01  4.331e+03   0.011  0.99117
## x               -1.438e-02  1.621e-02  -0.887  0.37498
## y                1.796e-02  1.062e-02   1.691  0.09086 .
## start_speed     -3.305e-01  5.816e-01  -0.568  0.56982
## end_speed        1.305e-01  1.581e-01   0.825  0.40922
## sz_top           8.380e-01  1.011e+00   0.829  0.40712
## sz_bot           3.676e-01  1.052e+00   0.350  0.72666
## px              -3.698e-01  5.575e-01  -0.663  0.50714
## pz               5.774e-01  4.710e-01   1.226  0.22027
## x0               2.618e-01  3.470e-01   0.754  0.45061
## y0                      NA         NA      NA       NA
## z0              -2.719e-01  3.982e-01  -0.683  0.49480
## vx0              1.136e-01  1.381e-01   0.823  0.41072
## vy0             -2.127e-01  4.071e-01  -0.522  0.60140
## vz0             -1.967e-01  1.473e-01  -1.335  0.18183
## ax               3.755e-02  3.098e-02   1.212  0.22551
## ay              -2.311e-02  5.081e-02  -0.455  0.64918
## az              -3.089e-03  6.215e-02  -0.050  0.96035
## break_y         -3.087e+00  1.952e+00  -1.582  0.11366
## break_length     2.243e-01  1.959e-01   1.145  0.25221
## spin_dir         2.884e-03  4.366e-03   0.660  0.50894
## spin_rate       -1.923e-05  3.034e-04  -0.063  0.94947
## trf_num_pitches  2.782e-02  9.278e-03   2.999  0.00271 **
## trf_num_AB       3.076e-01  7.137e-01   0.431  0.66642
## trf_num_AS       1.708e+01  3.531e+03   0.005  0.99614
## trf_num_CH      -1.502e-02  5.985e-03  -2.510  0.01206 *
```

```
## trf_num_CU       3.915e-03  5.493e-03   0.713  0.47598
## trf_num_EP      -8.667e-03  3.930e-02  -0.221  0.82547
## trf_num_FA       4.091e-02  5.976e-02   0.685  0.49366
## trf_num_FC      -3.243e-03  4.874e-03  -0.665  0.50578
## trf_num_FF       2.446e-04  6.576e-03   0.037  0.97034
## trf_num_FO      -1.027e-02  3.799e-02  -0.270  0.78703
## trf_num_FS      -7.668e-03  6.925e-03  -1.107  0.26814
## trf_num_FT      -4.951e-03  5.041e-03  -0.982  0.32606
## trf_num_IN      -4.556e-02  1.895e-02  -2.404  0.01621 *
## trf_num_KC      -1.855e-03  6.919e-03  -0.268  0.78867
## trf_num_KN      -1.538e-02  1.501e-02  -1.025  0.30532
## trf_num_PO       2.985e-02  4.956e-02   0.602  0.54695
## trf_num_SC      -1.106e+01  1.908e+02  -0.058  0.95379
## trf_num_SI      -8.891e-03  5.803e-03  -1.532  0.12550
## trf_num_SL      -1.868e-03  9.015e-03  -0.207  0.83583
## trf_num_UN       6.808e-04  1.120e-02   0.061  0.95154
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 3667.1  on 3245  degrees of freedom
## Residual deviance: 3322.1  on 3205  degrees of freedom
## AIC: 3404.1
##
## Number of Fisher Scoring iterations: 16
```

COefficients

```
mod_1$coefficients;
```

```
##     (Intercept)               x               y     start_speed
##    4.790750e+01   -1.438374e-02    1.795870e-02   -3.305324e-01
##       end_speed          sz_top          sz_bot              px
##    1.305043e-01    8.380272e-01    3.676150e-01   -3.698234e-01
##              pz              x0              y0              z0
##    5.773934e-01    2.617837e-01              NA   -2.718682e-01
##             vx0             vy0             vz0              ax
##    1.136216e-01   -2.126678e-01   -1.967318e-01    3.754882e-02
##              ay              az         break_y    break_length
##   -2.311265e-02   -3.089469e-03   -3.087421e+00    2.243344e-01
##        spin_dir       spin_rate trf_num_pitches      trf_num_AB
##    2.883562e-03   -1.922527e-05    2.782237e-02    3.076493e-01
##      trf_num_AS      trf_num_CH      trf_num_CU      trf_num_EP
##    1.707741e+01   -1.502439e-02    3.915119e-03   -8.666885e-03
##      trf_num_FA      trf_num_FC      trf_num_FF      trf_num_FO
##    4.090886e-02   -3.243093e-03    2.445568e-04   -1.026509e-02
##      trf_num_FS      trf_num_FT      trf_num_IN      trf_num_KC
##   -7.668036e-03   -4.951131e-03   -4.555533e-02   -1.854666e-03
##      trf_num_KN      trf_num_PO      trf_num_SC      trf_num_SI
##   -1.538422e-02    2.985496e-02   -1.105629e+01   -8.890802e-03
```

```
##      trf_num_SL      trf_num_UN
##   -1.868304e-03    6.808348e-04
```

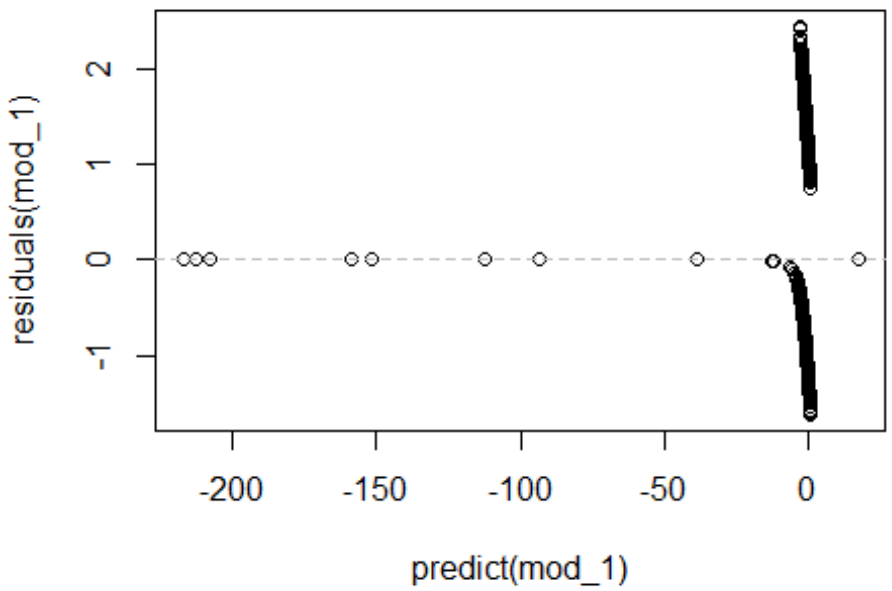
Odds Ratio

```
exp(mod_1$coefficients);
```

```
##     (Intercept)               x               y     start_speed
##    6.396778e+20    9.857192e-01    1.018121e+00    7.185411e-01
##       end_speed          sz_top          sz_bot              px
##    1.139403e+00    2.311802e+00    1.444286e+00    6.908563e-01
##              pz              x0              y0              z0
##    1.781389e+00    1.299246e+00              NA    7.619547e-01
##             vx0             vy0             vz0              ax
##    1.120328e+00    8.084246e-01    8.214109e-01    1.038263e+00
##              ay              az         break_y    break_length
##    9.771524e-01    9.969153e-01    4.561945e-02    1.251489e+00
##        spin_dir       spin_rate trf_num_pitches      trf_num_AB
##    1.002888e+00    9.999808e-01    1.028213e+00    1.360224e+00
##      trf_num_AS      trf_num_CH      trf_num_CU      trf_num_EP
##    2.609906e+07    9.850879e-01    1.003923e+00    9.913706e-01
##      trf_num_FA      trf_num_FC      trf_num_FF      trf_num_FO
##    1.041757e+00    9.967622e-01    1.000245e+00    9.897874e-01
##      trf_num_FS      trf_num_FT      trf_num_IN      trf_num_KC
##    9.923613e-01    9.950611e-01    9.554667e-01    9.981471e-01
##      trf_num_KN      trf_num_PO      trf_num_SC      trf_num_SI
##    9.847335e-01    1.030305e+00    1.578746e-05    9.911486e-01
##      trf_num_SL      trf_num_UN
##    9.981334e-01    1.000681e+00
```

Residual

```
plot(predict(mod_1),residuals(mod_1));
abline(h=0,lty=2,col="grey");
```



Performance

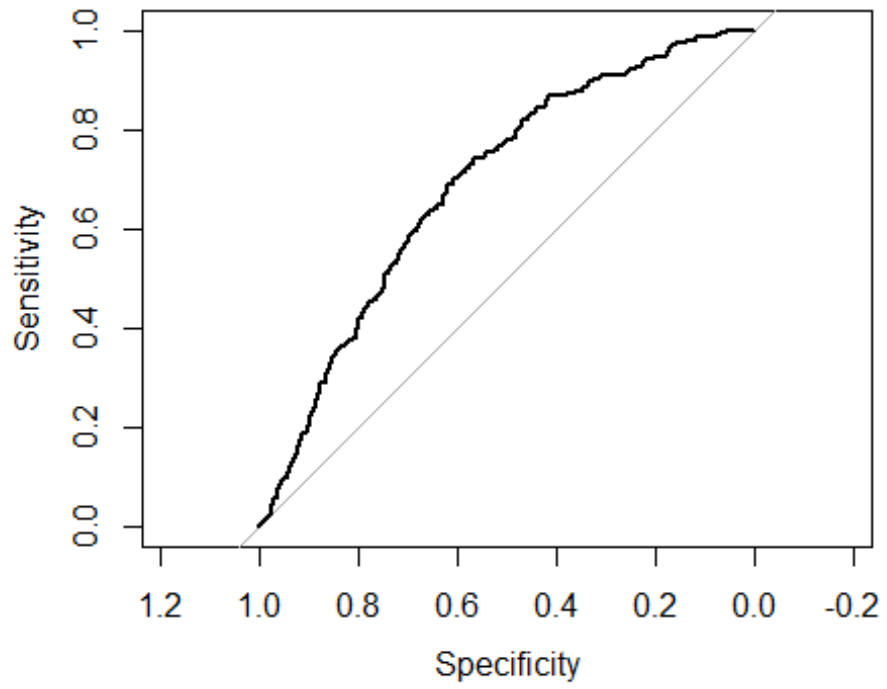
```
pred <- ifelse(predict(mod_1, testing, type='response') > threshold,  1, 0)
confusionMatrix(data=pred, reference=testing$OnDL, positive='1');
```

```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction   0   1
##          0 673 244
##          1  85  79
##
##                Accuracy : 0.6957
##                  95% CI : (0.6673, 0.723)
##     No Information Rate : 0.7012
##     P-Value [Acc > NIR] : 0.6684
##
##                   Kappa : 0.1542
##  Mcnemar's Test P-Value : <2e-16
##
##             Sensitivity : 0.24458
##             Specificity : 0.88786
##          Pos Pred Value : 0.48171
##          Neg Pred Value : 0.73391
##              Prevalence : 0.29880
##          Detection Rate : 0.07308
##    Detection Prevalence : 0.15171
```

```
##       Balanced Accuracy : 0.56622
##
##        'Positive' Class : 1
##
```

ROC curve

```
prob <- predict(mod_1, testing, type='response');
g1 <- roc(OnDL ~ prob, data = testing);
roc.curve(testing$OnDL, prob, plotit =F)

## Area under the curve (AUC): 0.690

plot(g1)
```



Model Building without outliers

Model 1(b) All variables

Create training and testing set using 75% training and 25% testing

```
train_lessOutliers <- createDataPartition(model_dataset_lessOutliers$OnDL, p=
0.75, list=FALSE);

training_lessOutliers <- model_dataset_lessOutliers[train_lessOutliers,];

testing_lessOutliers <- model_dataset_lessOutliers[-train_lessOutliers,];
```

Construct Model

```
selected_variables <- dependent_var;

selected_i <- which(colnames(training_lessOutliers) %in% selected_variables);

formula_text <- paste(response_var, "~",
                      paste(names(training_lessOutliers)[selected_i], collaps
e="+"));
formula <- as.formula(formula_text);

mod_1b = glm(formula = formula , family=binomial(logit), data=training_lessOu
tliers);
```

Summary

The summary shows that variables which have some significance to the outcomes are: end_speed, break_length, trf_num_pitches, trf_num_FA, trf_num_FT, trf_num_KN

```
summary(mod_1b);

##
## Call:
## glm(formula = formula, family = binomial(logit), data = training_lessOutli
ers)
##
## Deviance Residuals:
##     Min       1Q   Median       3Q      Max
## -1.6558  -0.7240  -0.5000  -0.1471   2.4884
##
## Coefficients: (2 not defined because of singularities)
##                   Estimate Std. Error z value Pr(>|z|)
## (Intercept)      8.745e+01  1.941e+04   0.005 0.996406
## x               -1.927e-02  2.064e-02  -0.934 0.350411
## y                2.512e-02  1.334e-02   1.883 0.059667 .
## start_speed     -1.310e+00  6.491e-01  -2.018 0.043632 *
## end_speed       -2.380e-02  1.773e-01  -0.134 0.893222
## sz_top          -2.253e-01  1.090e+00  -0.207 0.836265
## sz_bot           1.255e+00  1.144e+00   1.097 0.272603
## px               6.341e-02  6.925e-01   0.092 0.927040
## pz               1.608e+00  5.581e-01   2.881 0.003964 **
## x0              -6.459e-02  3.913e-01  -0.165 0.868904
## y0                      NA         NA      NA       NA
## z0              -1.352e+00  4.603e-01  -2.937 0.003316 **
## vx0              1.400e-02  1.543e-01   0.091 0.927698
## vy0             -1.025e+00  4.554e-01  -2.251 0.024390 *
## vz0             -6.471e-01  1.709e-01  -3.786 0.000153 ***
## ax               3.611e-02  3.505e-02   1.030 0.302869
## ay              -1.395e-01  5.681e-02  -2.455 0.014090 *
## az              -6.398e-02  7.528e-02  -0.850 0.395350
## break_y         -4.295e+00  2.111e+00  -2.035 0.041877 *
```

```
## break_length     3.159e-01  2.342e-01   1.349 0.177276
## spin_dir         1.688e-03  5.564e-03   0.303 0.761585
## spin_rate        2.461e-04  3.632e-04   0.677 0.498137
## trf_num_pitches  1.804e-02  1.058e-02   1.705 0.088223 .
## trf_num_AB              NA         NA      NA       NA
## trf_num_AS       1.991e+01  1.582e+04   0.001 0.998996
## trf_num_CH      -6.590e-03  6.584e-03  -1.001 0.316856
## trf_num_CU       5.427e-03  5.989e-03   0.906 0.364896
## trf_num_EP      -2.044e-01  1.251e-01  -1.634 0.102317
## trf_num_FA      -3.213e-01  1.056e-01  -3.044 0.002336 **
## trf_num_FC       4.582e-04  5.381e-03   0.085 0.932137
## trf_num_FF       1.002e-02  7.739e-03   1.295 0.195475
## trf_num_FO      -7.047e-02  2.939e-01  -0.240 0.810492
## trf_num_FS       3.050e-03  7.829e-03   0.390 0.696827
## trf_num_FT       2.912e-03  5.675e-03   0.513 0.607871
## trf_num_IN      -7.009e-02  2.049e-02  -3.421 0.000623 ***
## trf_num_KC      -2.082e-03  7.514e-03  -0.277 0.781735
## trf_num_KN      -9.878e+00  2.335e+02  -0.042 0.966259
## trf_num_PO       3.238e-02  5.354e-02   0.605 0.545362
## trf_num_SC      -1.321e+01  8.855e+02  -0.015 0.988097
## trf_num_SI      -3.658e-03  6.668e-03  -0.549 0.583337
## trf_num_SL       8.721e-03  1.002e-02   0.870 0.384217
## trf_num_UN      -7.347e-03  1.242e-02  -0.592 0.554040
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 3345.5  on 3089  degrees of freedom
## Residual deviance: 2897.1  on 3050  degrees of freedom
## AIC: 2977.1
##
## Number of Fisher Scoring iterations: 19
```

COefficients

```
mod_1b$coefficients;
```

```
##     (Intercept)              x              y     start_speed
##    8.744651e+01   -1.927374e-02    2.512222e-02   -1.309720e+00
##       end_speed          sz_top          sz_bot             px
##   -2.379882e-02   -2.252678e-01    1.255197e+00    6.340907e-02
##              pz              x0              y0             z0
##    1.607753e+00   -6.459042e-02              NA   -1.351931e+00
##             vx0             vy0             vz0             ax
##    1.399884e-02   -1.025046e+00   -6.470604e-01    3.611276e-02
##              ay              az         break_y    break_length
##   -1.394579e-01   -6.398053e-02   -4.295483e+00    3.159281e-01
##        spin_dir       spin_rate trf_num_pitches      trf_num_AB
##    1.688166e-03    2.460692e-04    1.804388e-02              NA
##      trf_num_AS      trf_num_CH      trf_num_CU      trf_num_EP
```

```
##    1.990627e+01   -6.589889e-03    5.426562e-03   -2.044280e-01
##      trf_num_FA      trf_num_FC      trf_num_FF      trf_num_FO
##   -3.212850e-01    4.582021e-04    1.001870e-02   -7.047383e-02
##      trf_num_FS      trf_num_FT      trf_num_IN      trf_num_KC
##    3.050274e-03    2.911716e-03   -7.008995e-02   -2.081670e-03
##      trf_num_KN      trf_num_PO      trf_num_SC      trf_num_SI
##   -9.878404e+00    3.237507e-02   -1.321116e+01   -3.657734e-03
##      trf_num_SL      trf_num_UN
##    8.720584e-03   -7.346978e-03
```

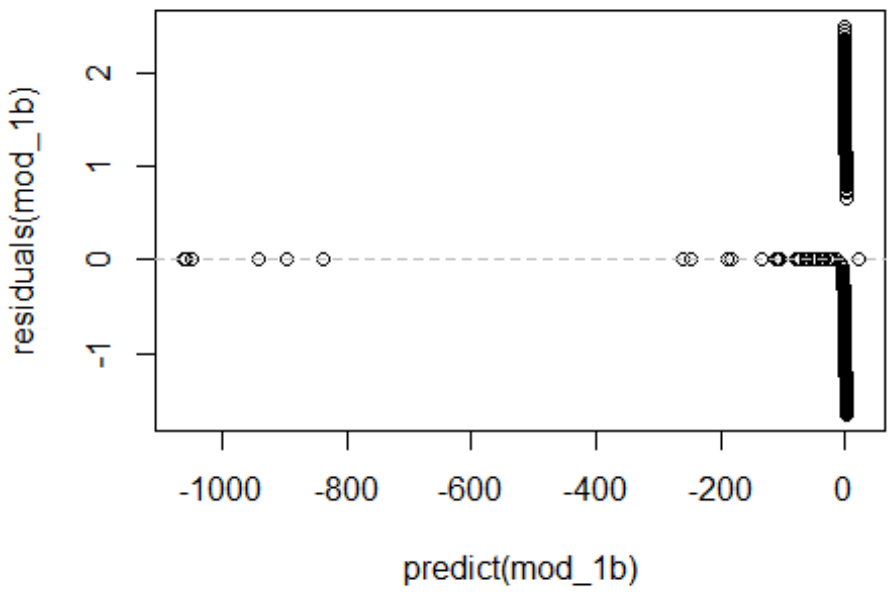
Odds Ratio

```
exp(mod_1b$coefficients);
```

```
##     (Intercept)               x               y     start_speed
##    9.495889e+37    9.809108e-01    1.025440e+00    2.698956e-01
##       end_speed          sz_top          sz_bot              px
##    9.764821e-01    7.983024e-01    3.508529e+00    1.065463e+00
##              pz              x0              y0              z0
##    4.991581e+00    9.374513e-01              NA    2.587402e-01
##             vx0             vy0             vz0              ax
##    1.014097e+00    3.587801e-01    5.235827e-01    1.036773e+00
##              ay              az         break_y    break_length
##    8.698297e-01    9.380233e-01    1.362999e-02    1.371532e+00
##        spin_dir       spin_rate trf_num_pitches      trf_num_AB
##    1.001690e+00    1.000246e+00    1.018208e+00              NA
##      trf_num_AS      trf_num_CH      trf_num_CU      trf_num_EP
##    4.417553e+08    9.934318e-01    1.005441e+00    8.151135e-01
##      trf_num_FA      trf_num_FC      trf_num_FF      trf_num_FO
##    7.252165e-01    1.000458e+00    1.010069e+00    9.319521e-01
##      trf_num_FS      trf_num_FT      trf_num_IN      trf_num_KC
##    1.003055e+00    1.002916e+00    9.323100e-01    9.979205e-01
##      trf_num_KN      trf_num_PO      trf_num_SC      trf_num_SI
##    5.127003e-05    1.032905e+00    1.830061e-06    9.963489e-01
##      trf_num_SL      trf_num_UN
##    1.008759e+00    9.926799e-01
```

Residual

```
plot(predict(mod_1b),residuals(mod_1b));
abline(h=0,lty=2,col="grey");
```



Performance

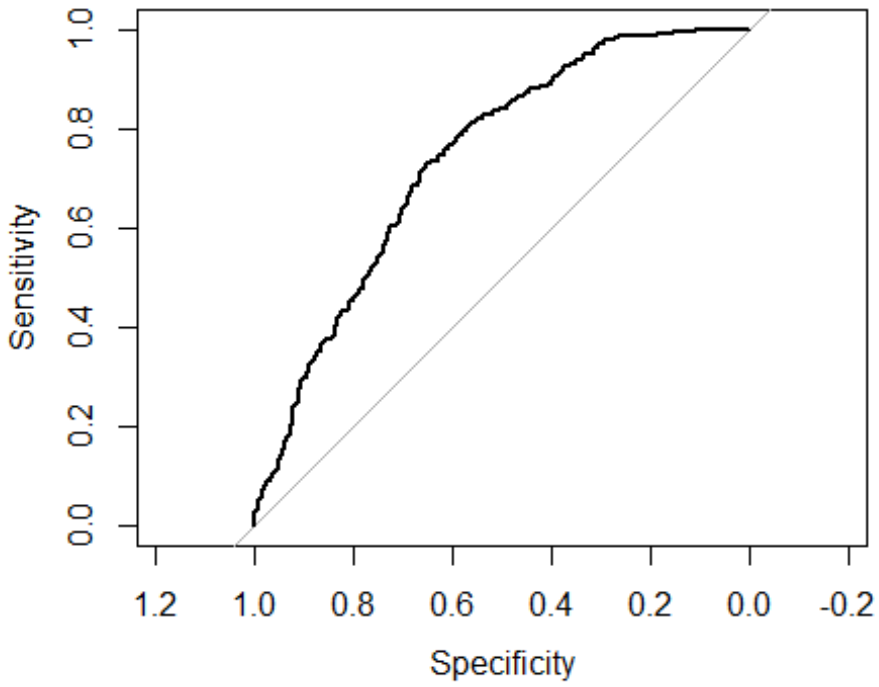
```
pred <- ifelse(predict(mod_1b, testing_lessOutliers, type='response') > thres
hold,  1, 0)
confusionMatrix(data=pred, reference=testing_lessOutliers$OnDL, positive='1')
;
```

```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction   0   1
##          0 678 174
##          1  91  87
##
##                Accuracy : 0.7427
##                  95% CI : (0.7149, 0.7692)
##     No Information Rate : 0.7466
##     P-Value [Acc > NIR] : 0.6284
##
##                   Kappa : 0.2402
##  Mcnemar's Test P-Value : 4.723e-07
##
##             Sensitivity : 0.33333
##             Specificity : 0.88166
##          Pos Pred Value : 0.48876
##          Neg Pred Value : 0.79577
##              Prevalence : 0.25340
```

```
##          Detection Rate : 0.08447
##    Detection Prevalence : 0.17282
##       Balanced Accuracy : 0.60750
##
##        'Positive' Class : 1
##
```

ROC curve

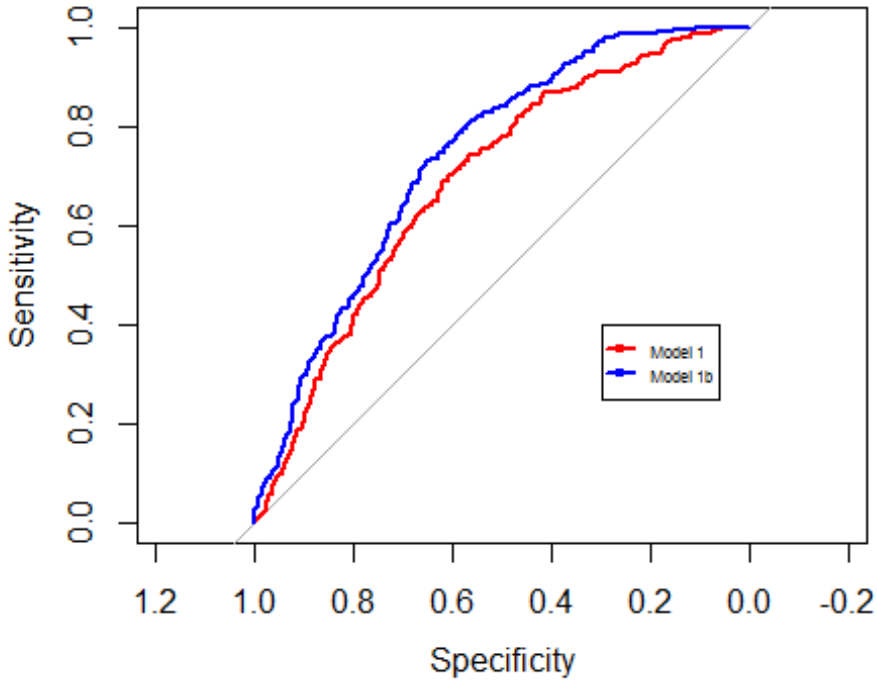
```
prob <- predict(mod_1b, testing_lessOutliers, type='response');
g1b <- roc(OnDL ~ prob, data = testing_lessOutliers);
roc.curve(testing_lessOutliers$OnDL, prob, plotit =F)

## Area under the curve (AUC): 0.738

plot(g1b)
```



Compare ROC of model with outliers vs model without outliers

The comparison of the ROC curve between the model with outliers (red) and one without outliers (blue) shows that the model has better performance once outliers are removed.

```
plot(g1, col='red')
plot(g1b, add=TRUE, col='blue')

legend(0.3,0.4,       c("Model 1","Model 1b"), lty=c(1,1), lwd=c(2.5,2.5),col
=c("red","blue"), pch=1, cex=0.5);
```



Model 2 Only low correlation variables (less than 0.25)

Low correlation variables

```
highlyCorDescr <- findCorrelation(m_lessOutliers, cutoff = .25)

lowCorColNames<- colnames(numeric_dataset[,-highlyCorDescr]);

print(lowCorColNames);
```

```
##  [1] "x"          "sz_top"     "pz"         "x0"         "vz0"
##  [6] "break_y"    "trf_num_AB" "trf_num_CU" "trf_num_EP" "trf_num_FA"
## [11] "trf_num_FF" "trf_num_FO" "trf_num_FT" "trf_num_IN" "trf_num_PO"
## [16] "trf_num_SC" "trf_num_UN"
```

Construct Model

```
selected_variables <- lowCorColNames;

selected_i <- which(colnames(training_lessOutliers) %in% selected_variables);

formula_text <- paste(response_var, "~",
                      paste(names(training_lessOutliers)[selected_i], collaps
e="+"));
formula <- as.formula(formula_text);
```

```
mod_2 = glm(formula = formula , family=binomial(logit), data=training_lessOut
liers);
```

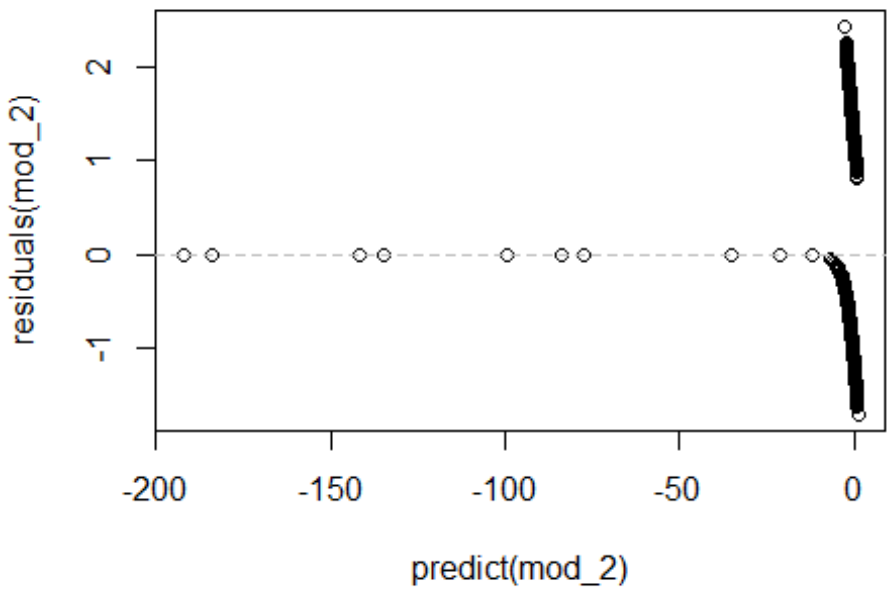
Summary

```
summary(mod_2);
```

```
##
## Call:
## glm(formula = formula, family = binomial(logit), data = training_lessOutli
ers)
##
## Deviance Residuals:
##     Min       1Q   Median       3Q      Max
## -1.6961  -0.7253  -0.5435  -0.3083   2.4255
##
## Coefficients: (1 not defined because of singularities)
##               Estimate Std. Error z value Pr(>|z|)
## (Intercept)  65.165651 249.595378   0.261  0.79403
## x             0.001452   0.006082   0.239  0.81131
## sz_top        0.720973   0.904091   0.797  0.42519
## pz           -0.467048   0.239939  -1.947  0.05159 .
## x0           -0.024572   0.027743  -0.886  0.37578
## vz0          -0.152128   0.032356  -4.702 2.58e-06 ***
## break_y      -2.395364   1.647853  -1.454  0.14605
## trf_num_AB          NA         NA      NA       NA
## trf_num_CU    0.006271   0.003773   1.662  0.09649 .
## trf_num_EP   -0.224243   0.116947  -1.917  0.05518 .
## trf_num_FA   -0.283122   0.100639  -2.813  0.00490 **
## trf_num_FF    0.019190   0.003042   6.308 2.82e-10 ***
## trf_num_FO   -0.131495   0.277602  -0.474  0.63573
## trf_num_FT    0.011969   0.002833   4.225 2.39e-05 ***
## trf_num_IN   -0.029048   0.019056  -1.524  0.12742
## trf_num_PO    0.041881   0.051433   0.814  0.41549
## trf_num_SC   -9.763217 201.230702  -0.049  0.96130
## trf_num_UN    0.012164   0.003798   3.203  0.00136 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 3345.5  on 3089  degrees of freedom
## Residual deviance: 3018.0  on 3073  degrees of freedom
## AIC: 3052
##
## Number of Fisher Scoring iterations: 16
```

Residual

```
plot(predict(mod_2),residuals(mod_2));
abline(h=0,lty=2,col="grey");
```



COefficients

```
mod_2$coefficients;
```

```
##  (Intercept)            x       sz_top           pz           x0
## 65.165650877  0.001451894  0.720972800 -0.467047727 -0.024571987
##          vz0      break_y   trf_num_AB   trf_num_CU   trf_num_EP
## -0.152127964 -2.395363802           NA  0.006271082 -0.224243237
##   trf_num_FA   trf_num_FF   trf_num_FO   trf_num_FT   trf_num_IN
## -0.283122269  0.019189752 -0.131495281  0.011968967 -0.029048234
##   trf_num_PO   trf_num_SC   trf_num_UN
##  0.041880740 -9.763217477  0.012163559
```

Odds ratio

```
exp(mod_2$coefficients);
```

```
##  (Intercept)            x       sz_top           pz           x0
## 2.000242e+28 1.001453e+00 2.056433e+00 6.268502e-01 9.757274e-01
##          vz0      break_y   trf_num_AB   trf_num_CU   trf_num_EP
## 8.588784e-01 9.113952e-02           NA 1.006291e+00 7.991207e-01
##   trf_num_FA   trf_num_FF   trf_num_FO   trf_num_FT   trf_num_IN
## 7.534277e-01 1.019375e+00 8.767834e-01 1.012041e+00 9.713696e-01
##   trf_num_PO   trf_num_SC   trf_num_UN
## 1.042770e+00 5.752923e-05 1.012238e+00
```

Performance

```
pred <- ifelse(predict(mod_2, testing_lessOutliers, type='response') > thresh
old,  1, 0);
confusionMatrix(data=pred, reference=testing_lessOutliers$OnDL, positive='1')
;
```

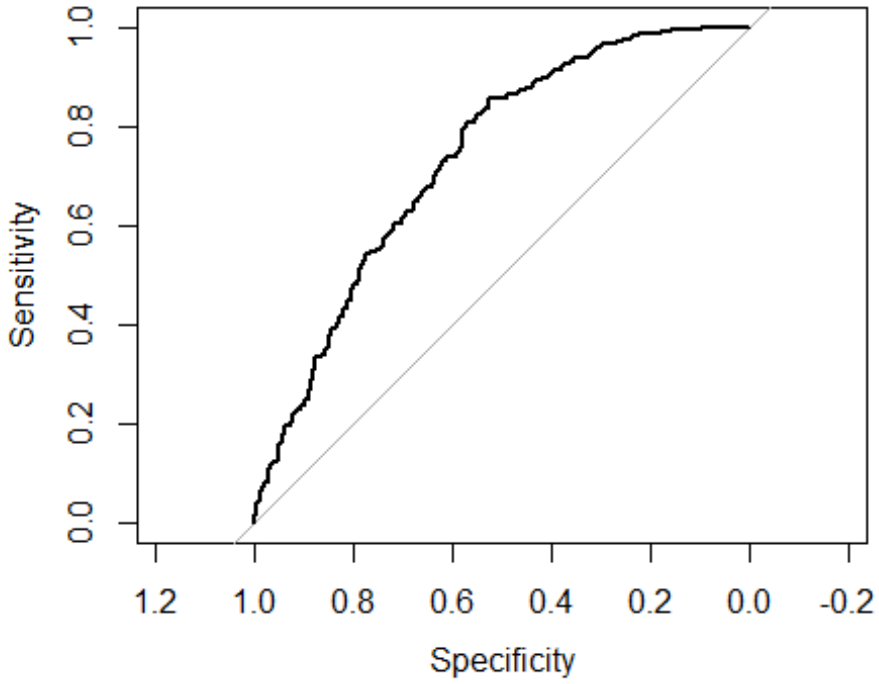
```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction   0   1
##          0 688 196
##          1  81  65
##
##                Accuracy : 0.7311
##                  95% CI : (0.7029, 0.7579)
##     No Information Rate : 0.7466
##     P-Value [Acc > NIR] : 0.881
##
##                   Kappa : 0.1682
##  Mcnemar's Test P-Value : 7.406e-12
##
##             Sensitivity : 0.24904
##             Specificity : 0.89467
##          Pos Pred Value : 0.44521
##          Neg Pred Value : 0.77828
##              Prevalence : 0.25340
##          Detection Rate : 0.06311
##    Detection Prevalence : 0.14175
##       Balanced Accuracy : 0.57186
##
##        'Positive' Class : 1
##
```

ROC curve

```
prob <- predict(mod_2, testing_lessOutliers, type='response');
g2 <- roc(OnDL ~ prob, data = testing_lessOutliers);
roc.curve(testing_lessOutliers$OnDL, prob, plotit = F);
```

```
## Area under the curve (AUC): 0.734
```

```
plot(g2)
```



Model 2(b) Only low correlation variables (less than 0.5)

Low correlation variables

```
highlyCorDescr <- findCorrelation(m_lessOutliers, cutoff = .5)

lowCorColNames<- colnames(numeric_dataset[,-highlyCorDescr]);

print(lowCorColNames);
```

```
##  [1] "sz_top"     "px"         "pz"         "x0"         "z0"
##  [6] "ay"         "break_y"    "spin_rate"  "trf_num_AB" "trf_num_AS"
## [11] "trf_num_CH" "trf_num_EP" "trf_num_FA" "trf_num_FF" "trf_num_FO"
## [16] "trf_num_FS" "trf_num_FT" "trf_num_IN" "trf_num_KC" "trf_num_KN"
## [21] "trf_num_PO" "trf_num_SC" "trf_num_SI" "trf_num_UN"
```

Construct Model

```
selected_variables <- lowCorColNames;

selected_i <- which(colnames(training_lessOutliers) %in% selected_variables);

formula_text <- paste(response_var, "~",
                      paste(names(training_lessOutliers)[selected_i], collaps
e="+"));
formula <- as.formula(formula_text);
```

```
mod_2b = glm(formula = formula , family=binomial(logit), data=training_lessOu
tliers);
```

Summary

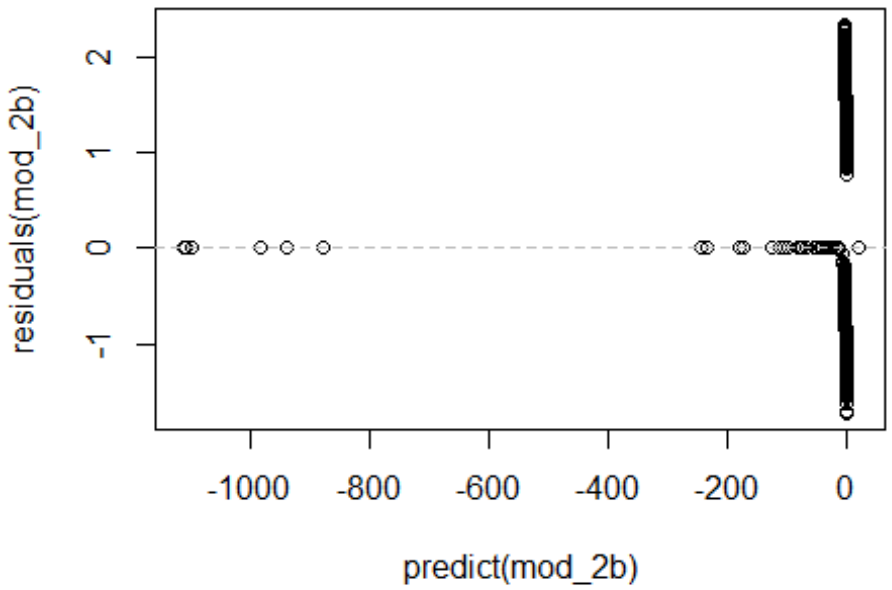
```
summary(mod_2b);
```

```
##
## Call:
## glm(formula = formula, family = binomial(logit), data = training_lessOutli
ers)
##
## Deviance Residuals:
##     Min       1Q   Median       3Q      Max
## -1.7172  -0.7251  -0.5341  -0.2341   2.3303
##
## Coefficients: (1 not defined because of singularities)
##               Estimate Std. Error z value Pr(>|z|)
## (Intercept) -2.013e+01  1.941e+04  -0.001 0.999172
## sz_top       5.412e-01  8.885e-01   0.609 0.542424
## px           7.273e-01  2.483e-01   2.929 0.003402 **
## pz          -6.711e-01  2.522e-01  -2.662 0.007778 **
## x0          -8.171e-03  2.957e-02  -0.276 0.782308
## z0           2.890e-01  1.168e-01   2.475 0.013319 *
## ay           9.663e-02  2.728e-02   3.542 0.000397 ***
## break_y      7.546e-01  1.877e+00   0.402 0.687755
## spin_rate    3.942e-05  1.956e-04   0.202 0.840266
## trf_num_AB          NA         NA      NA       NA
## trf_num_AS   1.948e+01  1.582e+04   0.001 0.999018
## trf_num_CH  -6.219e-03  5.001e-03  -1.244 0.213621
## trf_num_EP  -2.006e-01  1.198e-01  -1.675 0.094014 .
## trf_num_FA  -2.956e-01  1.036e-01  -2.853 0.004329 **
## trf_num_FF   2.764e-02  3.511e-03   7.873 3.45e-15 ***
## trf_num_FO  -1.471e-01  3.005e-01  -0.490 0.624463
## trf_num_FS   4.882e-03  6.628e-03   0.737 0.461358
## trf_num_FT   2.047e-02  3.412e-03   5.999 1.99e-09 ***
## trf_num_IN  -5.681e-02  1.956e-02  -2.905 0.003670 **
## trf_num_KC  -4.111e-03  5.666e-03  -0.725 0.468177
## trf_num_KN  -1.036e+01  2.377e+02  -0.044 0.965251
## trf_num_PO   9.465e-03  5.221e-02   0.181 0.856149
## trf_num_SC  -1.244e+01  8.730e+02  -0.014 0.988627
## trf_num_SI   1.504e-02  3.443e-03   4.368 1.25e-05 ***
## trf_num_UN   4.738e-03  3.990e-03   1.188 0.234980
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 3345.5  on 3089  degrees of freedom
## Residual deviance: 2976.2  on 3066  degrees of freedom
## AIC: 3024.2
```

```
##
## Number of Fisher Scoring iterations: 19
```

Residual

```
plot(predict(mod_2b),residuals(mod_2b));
abline(h=0,lty=2,col="grey");
```



COefficients

```
mod_2b$coefficients;
```

```
##   (Intercept)        sz_top            px            pz            x0
## -2.013386e+01  5.412250e-01  7.272884e-01 -6.711160e-01 -8.170812e-03
##            z0            ay       break_y     spin_rate    trf_num_AB
##  2.890383e-01  9.663075e-02  7.545614e-01  3.941815e-05            NA
##    trf_num_AS    trf_num_CH    trf_num_EP    trf_num_FA    trf_num_FF
##  1.948419e+01 -6.219403e-03 -2.005616e-01 -2.955782e-01  2.764281e-02
##    trf_num_FO    trf_num_FS    trf_num_FT    trf_num_IN    trf_num_KC
## -1.470926e-01  4.882289e-03  2.046642e-02 -5.681122e-02 -4.110602e-03
##    trf_num_KN    trf_num_PO    trf_num_SC    trf_num_SI    trf_num_UN
## -1.035637e+01  9.464679e-03 -1.244472e+01  1.503747e-02  4.738141e-03
```

Odds ratio

```
exp(mod_2b$coefficients);
```

```
##  (Intercept)       sz_top           px           pz           x0
## 1.802916e-09 1.718110e+00 2.069461e+00 5.111378e-01 9.918625e-01
##           z0           ay      break_y    spin_rate   trf_num_AB
```

```
## 1.335143e+00 1.101454e+00 2.126679e+00 1.000039e+00           NA
##   trf_num_AS   trf_num_CH   trf_num_EP   trf_num_FA   trf_num_FF
## 2.896521e+08 9.937999e-01 8.182710e-01 7.441013e-01 1.028028e+00
##   trf_num_FO   trf_num_FS   trf_num_FT   trf_num_IN   trf_num_KC
## 8.632140e-01 1.004894e+00 1.020677e+00 9.447724e-01 9.958978e-01
##   trf_num_KN   trf_num_PO   trf_num_SC   trf_num_SI   trf_num_UN
## 3.178965e-05 1.009510e+00 3.938474e-06 1.015151e+00 1.004749e+00
```

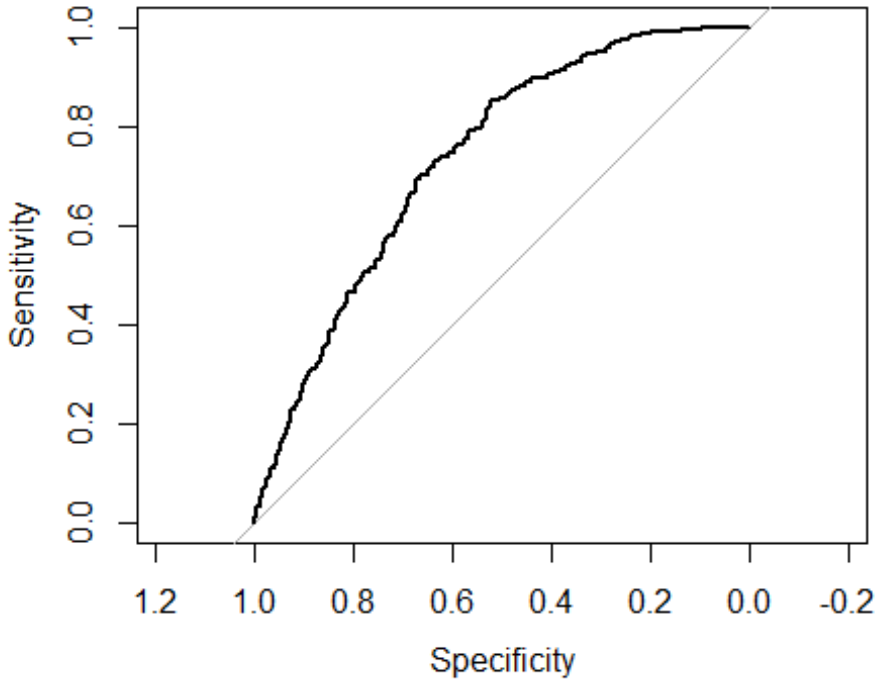
Performance

```
pred <- ifelse(predict(mod_2b, testing_lessOutliers, type='response') > thres
hold,  1, 0);
confusionMatrix(data=pred, reference=testing_lessOutliers$OnDL, positive='1')
;
```

```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction   0   1
##          0 688 184
##          1  81  77
##
##                Accuracy : 0.7427
##                  95% CI : (0.7149, 0.7692)
##     No Information Rate : 0.7466
##     P-Value [Acc > NIR] : 0.6284
##
##                   Kappa : 0.2181
##  Mcnemar's Test P-Value : 3.709e-10
##
##             Sensitivity : 0.29502
##             Specificity : 0.89467
##          Pos Pred Value : 0.48734
##          Neg Pred Value : 0.78899
##              Prevalence : 0.25340
##          Detection Rate : 0.07476
##    Detection Prevalence : 0.15340
##       Balanced Accuracy : 0.59484
##
##        'Positive' Class : 1
##
```

ROC curve

```
prob <- predict(mod_2b, testing_lessOutliers, type='response');
g2b <- roc(OnDL ~ prob, data = testing_lessOutliers);
roc.curve(testing_lessOutliers$OnDL, prob, plotit = F);

## Area under the curve (AUC): 0.735

plot(g2b)
```



Model 2(c) Only low correlation variables (less than 0.75)

Low correlation variables

```
highlyCorDescr <- findCorrelation(m_lessOutliers, cutoff = .75);

lowCorColNames <- colnames(numeric_dataset_lessOutliers[,-highlyCorDescr]);


#filter_pitches_dl_dataset <-  filteredDescr[,-highlyCorDescr]
#all_variables <- colnames(numeric_dataset);
print(lowCorColNames);
```

```
##  [1] "x"          "y"          "sz_top"     "sz_bot"     "px"
##  [6] "pz"         "z0"         "vx0"        "ay"         "az"
## [11] "break_y"    "spin_rate"  "trf_num_AS" "trf_num_CH" "trf_num_CU"
## [16] "trf_num_EP" "trf_num_FA" "trf_num_FC" "trf_num_FF" "trf_num_FO"
## [21] "trf_num_FS" "trf_num_FT" "trf_num_IN" "trf_num_KC" "trf_num_KN"
## [26] "trf_num_PO" "trf_num_SC" "trf_num_SI" "trf_num_SL"
```

Construct Model

```
selected_variables <- lowCorColNames;

selected_i <- which(colnames(training) %in% selected_variables);

formula_text <- paste(response_var, "~",
```

```
                    paste(names(training_lessOutliers)[selected_i], collaps
e="+"));
formula <- as.formula(formula_text);

mod_2c = glm(formula = formula , family=binomial(logit), data=training_lessOu
tliers);
```

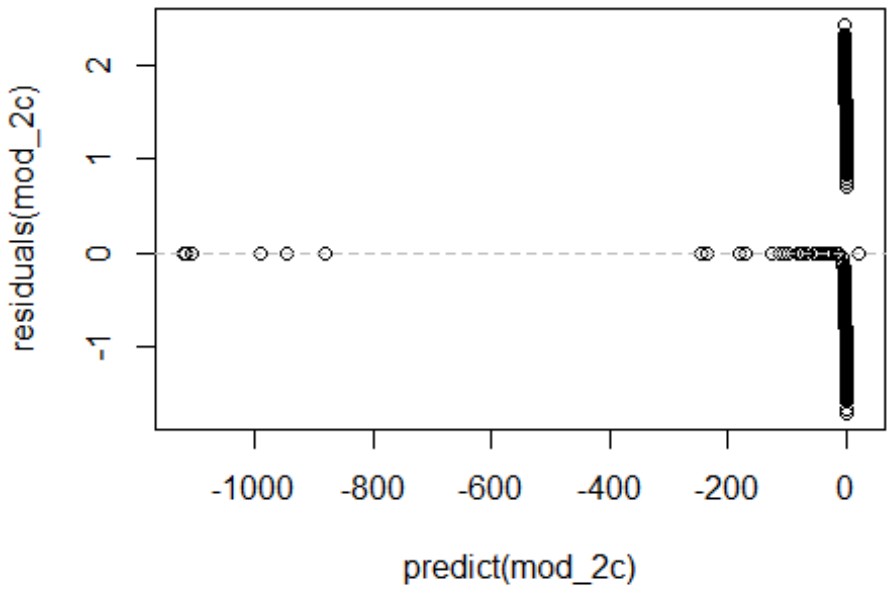
Summary

```
summary(mod_2c);

##
## Call:
## glm(formula = formula, family = binomial(logit), data = training_lessOutli
ers)
##
## Deviance Residuals:
##     Min       1Q   Median       3Q      Max
## -1.7091  -0.7280  -0.5256  -0.2240   2.4339
##
## Coefficients:
##               Estimate Std. Error z value Pr(>|z|)
## (Intercept) -2.813e+01  1.941e+04  -0.001 0.998844
## x           -2.709e-02  2.024e-02  -1.338 0.180755
## y            3.107e-02  1.307e-02   2.377 0.017431 *
## sz_top      -2.171e-01  8.399e-01  -0.259 0.796017
## sz_bot       2.763e-01  1.050e+00   0.263 0.792530
## px          -7.305e-02  6.004e-01  -0.122 0.903156
## pz           6.976e-02  3.797e-01   0.184 0.854236
## z0           3.181e-01  1.280e-01   2.485 0.012949 *
## vx0         -1.930e-04  9.099e-03  -0.021 0.983078
## ay           1.082e-01  2.900e-02   3.731 0.000191 ***
## az          -1.993e-02  1.916e-02  -1.040 0.298275
## break_y      9.775e-01  1.908e+00   0.512 0.608425
## spin_rate    2.693e-04  2.436e-04   1.105 0.268963
## trf_num_AS   1.949e+01  1.582e+04   0.001 0.999017
## trf_num_CH  -6.668e-03  5.034e-03  -1.325 0.185325
## trf_num_CU   2.059e-03  4.711e-03   0.437 0.662108
## trf_num_EP  -2.198e-01  1.236e-01  -1.778 0.075402 .
## trf_num_FA  -3.088e-01  1.046e-01  -2.952 0.003162 **
## trf_num_FC   8.043e-03  4.013e-03   2.004 0.045063 *
## trf_num_FF   2.571e-02  4.227e-03   6.081 1.19e-09 ***
## trf_num_FO  -1.258e-01  2.958e-01  -0.425 0.670727
## trf_num_FS   4.370e-03  6.745e-03   0.648 0.517059
## trf_num_FT   1.729e-02  3.812e-03   4.535 5.77e-06 ***
## trf_num_IN  -6.094e-02  1.972e-02  -3.090 0.002003 **
## trf_num_KC  -3.521e-03  6.457e-03  -0.545 0.585570
## trf_num_KN  -1.041e+01  2.354e+02  -0.044 0.964725
## trf_num_PO   1.520e-02  5.289e-02   0.287 0.773757
## trf_num_SC  -1.247e+01  8.749e+02  -0.014 0.988629
## trf_num_SI   1.128e-02  4.006e-03   2.815 0.004878 **
```

```
## trf_num_SL   7.549e-03  4.098e-03   1.842 0.065428 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 3345.5  on 3089  degrees of freedom
## Residual deviance: 2959.9  on 3060  degrees of freedom
## AIC: 3019.9
##
## Number of Fisher Scoring iterations: 19
```

Residual

```
plot(predict(mod_2c),residuals(mod_2c));
abline(h=0,lty=2,col="grey");
```



COefficients

```
mod_2c$coefficients;
```

```
##   (Intercept)             x             y        sz_top        sz_bot
## -2.813061e+01 -2.708802e-02  3.106750e-02 -2.171255e-01  2.762835e-01
##            px            pz            z0           vx0            ay
## -7.304863e-02  6.976023e-02  3.181179e-01 -1.929885e-04  1.081875e-01
##            az       break_y     spin_rate    trf_num_AS    trf_num_CH
## -1.993275e-02  9.774508e-01  2.692993e-04  1.948753e+01 -6.667687e-03
##    trf_num_CU    trf_num_EP    trf_num_FA    trf_num_FC    trf_num_FF
```

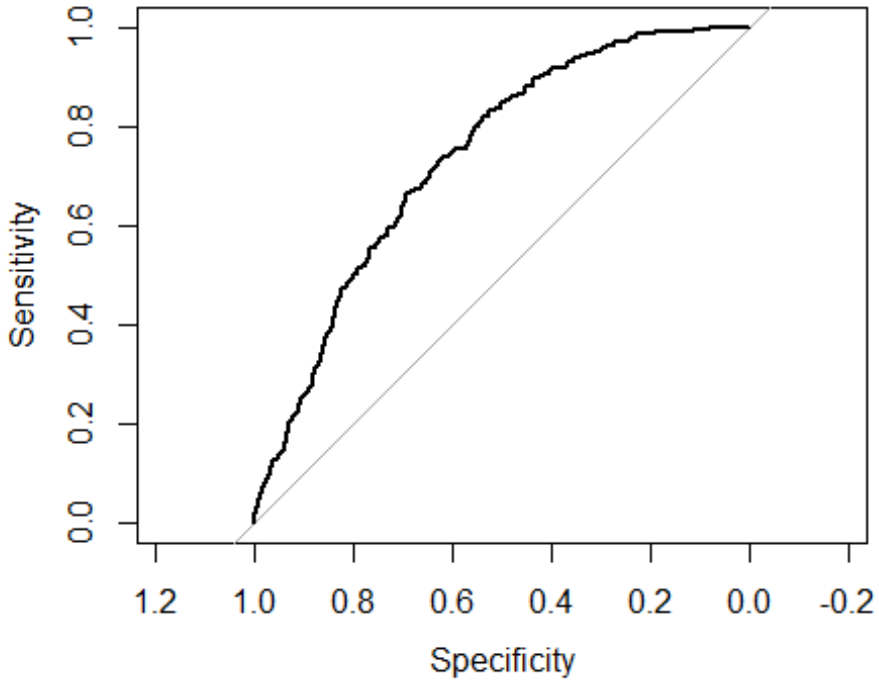
```
##  2.058678e-03 -2.198445e-01 -3.087691e-01  8.043021e-03  2.570561e-02
##    trf_num_FO    trf_num_FS    trf_num_FT    trf_num_IN    trf_num_KC
## -1.257593e-01  4.369897e-03  1.728698e-02 -6.093793e-02 -3.521058e-03
##    trf_num_KN    trf_num_PO    trf_num_SC    trf_num_SI    trf_num_SL
## -1.041132e+01  1.520469e-02 -1.246918e+01  1.127814e-02  7.549246e-03
```

Performance

```
pred <- ifelse(predict(mod_2c, testing_lessOutliers, type='response') > thres
hold,  1, 0);
confusionMatrix(data=pred, reference=testing_lessOutliers$OnDL, positive='1')
;

## Confusion Matrix and Statistics
##
##           Reference
## Prediction   0   1
##          0 680 189
##          1  89  72
##
##                Accuracy : 0.7301
##                  95% CI : (0.7019, 0.757)
##     No Information Rate : 0.7466
##     P-Value [Acc > NIR] : 0.8944
##
##                   Kappa : 0.1833
##  Mcnemar's Test P-Value : 2.892e-09
##
##             Sensitivity : 0.2759
##             Specificity : 0.8843
##          Pos Pred Value : 0.4472
##          Neg Pred Value : 0.7825
##              Prevalence : 0.2534
##          Detection Rate : 0.0699
##    Detection Prevalence : 0.1563
##       Balanced Accuracy : 0.5801
##
##        'Positive' Class : 1
##
```

ROC curve

```
prob <- predict(mod_2c, testing_lessOutliers, type='response');
g2c <- roc(OnDL ~ prob, data = testing_lessOutliers);
roc.curve(testing_lessOutliers$OnDL, prob, plotit = F)

## Area under the curve (AUC): 0.736

plot(g2c)
```



Model 2(d) Only low correlation variables (less than 0.85)

Low correlation variables

```
highlyCorDescr <- findCorrelation(m_lessOutliers, cutoff =0.85);

lowCorColNames <- colnames(numeric_dataset_lessOutliers[,-highlyCorDescr]);


#filter_pitches_dl_dataset <-  filteredDescr[,-highlyCorDescr]
#all_variables <- colnames(numeric_dataset);
print(lowCorColNames);
```

```
##  [1] "x"              "y"              "end_speed"
##  [4] "sz_top"         "sz_bot"         "px"
##  [7] "pz"             "z0"             "vx0"
## [10] "vz0"            "ay"             "az"
## [13] "break_y"        "spin_rate"      "trf_num_pitches"
## [16] "trf_num_AS"     "trf_num_CH"     "trf_num_CU"
## [19] "trf_num_EP"     "trf_num_FA"     "trf_num_FC"
## [22] "trf_num_FF"     "trf_num_FO"     "trf_num_FS"
## [25] "trf_num_FT"     "trf_num_IN"     "trf_num_KC"
## [28] "trf_num_KN"     "trf_num_PO"     "trf_num_SC"
## [31] "trf_num_SI"     "trf_num_SL"
```

Construct Model

```
selected_variables <- lowCorColNames;

selected_i <- which(colnames(training) %in% selected_variables);

formula_text <- paste(response_var, "~",
                      paste(names(training_lessOutliers)[selected_i], collaps
e="+"));
formula <- as.formula(formula_text);

mod_2d = glm(formula = formula , family=binomial(logit), data=training_lessOu
tliers);
```

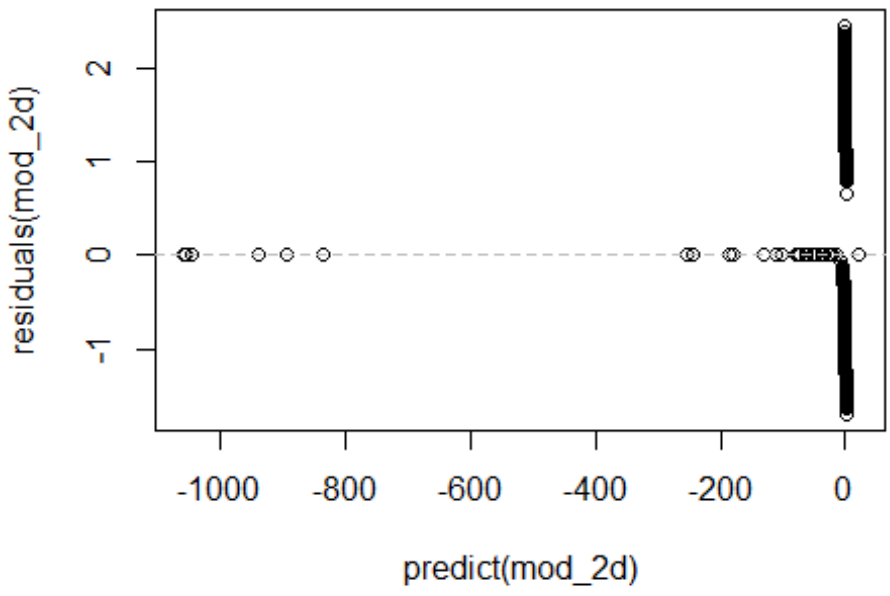
Summary

```
summary(mod_2d);

##
## Call:
## glm(formula = formula, family = binomial(logit), data = training_lessOutli
ers)
##
## Deviance Residuals:
##     Min       1Q   Median       3Q      Max
## -1.6953  -0.7265  -0.5076  -0.1613   2.4513
##
## Coefficients:
##                   Estimate Std. Error z value Pr(>|z|)
## (Intercept)      8.086e+01  1.941e+04   0.004 0.996676
## x               -2.148e-02  2.028e-02  -1.059 0.289458
## y                2.628e-02  1.308e-02   2.008 0.044595 *
## end_speed        1.271e-01  3.646e-02   3.485 0.000492 ***
## sz_top          -2.695e-01  1.062e+00  -0.254 0.799664
## sz_bot           1.269e+00  1.088e+00   1.166 0.243416
## px               8.385e-02  5.972e-01   0.140 0.888343
## pz               1.437e+00  5.271e-01   2.726 0.006401 **
## z0              -1.137e+00  4.344e-01  -2.616 0.008885 **
## vx0             -1.161e-02  9.446e-03  -1.229 0.219073
## vz0             -5.541e-01  1.569e-01  -3.532 0.000412 ***
## ay              -8.587e-02  4.104e-02  -2.092 0.036427 *
## az              -1.236e-01  3.085e-02  -4.005  6.2e-05 ***
## break_y         -3.890e+00  2.094e+00  -1.857 0.063249 .
## spin_rate        3.544e-04  2.459e-04   1.441 0.149553
## trf_num_pitches  1.397e-02  9.447e-03   1.479 0.139142
## trf_num_AS       1.998e+01  1.582e+04   0.001 0.998993
## trf_num_CH      -5.264e-03  6.314e-03  -0.834 0.404403
## trf_num_CU       5.516e-03  5.821e-03   0.948 0.343335
## trf_num_EP      -2.093e-01  1.241e-01  -1.687 0.091592 .
## trf_num_FA      -3.115e-01  1.056e-01  -2.949 0.003185 **
## trf_num_FC       2.916e-03  5.205e-03   0.560 0.575280
```

```
## trf_num_FF       1.153e-02  7.379e-03   1.563 0.118078
## trf_num_FO      -5.915e-02  2.892e-01  -0.205 0.837960
## trf_num_FS       3.038e-03  7.642e-03   0.398 0.690997
## trf_num_FT       5.631e-03  5.361e-03   1.050 0.293493
## trf_num_IN      -6.793e-02  2.034e-02  -3.340 0.000838 ***
## trf_num_KC      -9.364e-04  7.354e-03  -0.127 0.898675
## trf_num_KN      -9.848e+00  2.302e+02  -0.043 0.965874
## trf_num_PO       2.881e-02  5.343e-02   0.539 0.589717
## trf_num_SC      -1.291e+01  8.653e+02  -0.015 0.988094
## trf_num_SI      -1.352e-03  6.268e-03  -0.216 0.829158
## trf_num_SL       4.945e-03  5.532e-03   0.894 0.371385
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 3345.5  on 3089  degrees of freedom
## Residual deviance: 2910.1  on 3057  degrees of freedom
## AIC: 2976.1
##
## Number of Fisher Scoring iterations: 19
```

Residual

```
plot(predict(mod_2d),residuals(mod_2d));
abline(h=0,lty=2,col="grey");
```



COefficients

```
exp(mod_2d$coefficients);
```

```
##     (Intercept)               x               y       end_speed
##    1.309692e+35    9.787465e-01    1.026627e+00    1.135513e+00
##          sz_top          sz_bot              px              pz
##    7.637463e-01    3.558145e+00    1.087466e+00    4.208748e+00
##              z0             vx0             vz0              ay
##    3.209218e-01    9.884575e-01    5.745706e-01    9.177123e-01
##              az         break_y      spin_rate trf_num_pitches
##    8.837658e-01    2.044149e-02    1.000354e+00    1.014070e+00
##      trf_num_AS      trf_num_CH      trf_num_CU      trf_num_EP
##    4.738614e+08    9.947494e-01    1.005531e+00    8.111271e-01
##      trf_num_FA      trf_num_FC      trf_num_FF      trf_num_FO
##    7.323249e-01    1.002920e+00    1.011600e+00    9.425663e-01
##      trf_num_FS      trf_num_FT      trf_num_IN      trf_num_KC
##    1.003043e+00    1.005647e+00    9.343268e-01    9.990641e-01
##      trf_num_KN      trf_num_PO      trf_num_SC      trf_num_SI
##    5.284055e-05    1.029233e+00    2.464992e-06    9.986484e-01
##      trf_num_SL
##    1.004957e+00
```

Performance

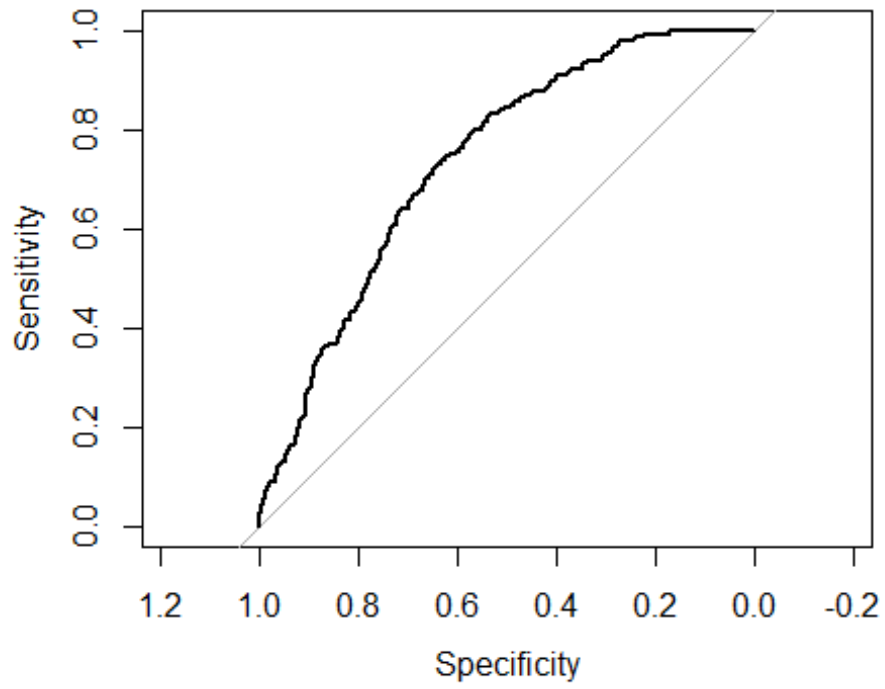
```
pred <- ifelse(predict(mod_2d, testing_lessOutliers, type='response') > thres
hold,  1, 0);
confusionMatrix(data=pred, reference=testing_lessOutliers$OnDL, positive='1')
;
```

```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction   0   1
##          0 677 174
##          1  92  87
##
##                Accuracy : 0.7417
##                  95% CI : (0.7139, 0.7682)
##     No Information Rate : 0.7466
##     P-Value [Acc > NIR] : 0.655
##
##                   Kappa : 0.2384
##  Mcnemar's Test P-Value : 6.82e-07
##
##             Sensitivity : 0.33333
##             Specificity : 0.88036
##          Pos Pred Value : 0.48603
##          Neg Pred Value : 0.79553
##              Prevalence : 0.25340
##          Detection Rate : 0.08447
##    Detection Prevalence : 0.17379
```

```
##       Balanced Accuracy : 0.60685
##
##        'Positive' Class : 1
##
```

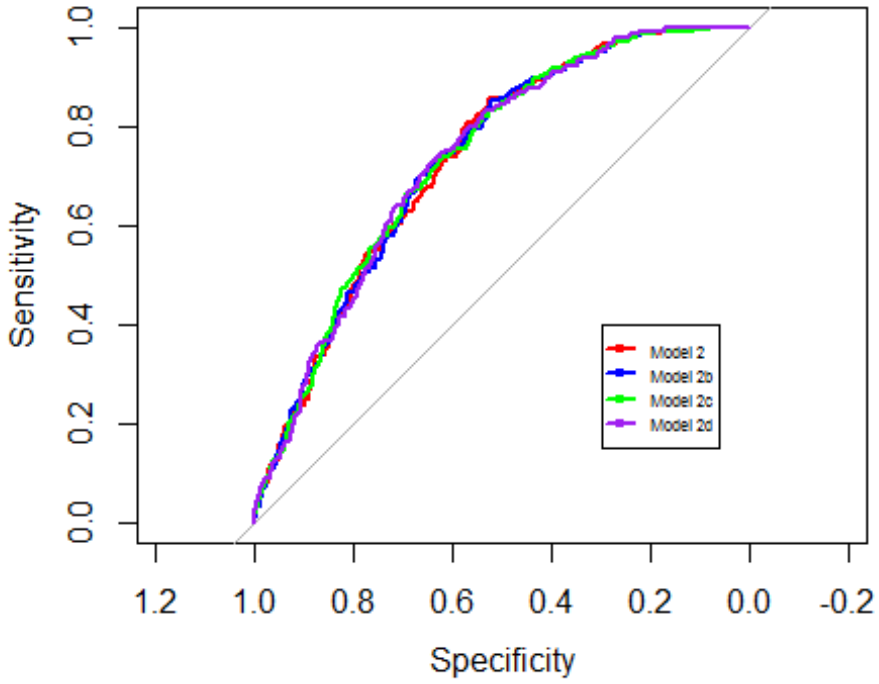
ROC curve

```
prob <- predict(mod_2d, testing_lessOutliers, type='response');
g2d <- roc(OnDL ~ prob, data = testing_lessOutliers);
roc.curve(testing_lessOutliers$OnDL, prob, plotit = F)

## Area under the curve (AUC): 0.736

plot(g2d)
```



Compare ROC Curve of model by correlation

```
plot(g2, col='red'); #cutoff 0.25
plot(g2b, add=TRUE, col='blue') #cutoff 0.5
plot(g2c, add=TRUE, col='green')  #cutoff 0.75
plot(g2d, add=TRUE, col='purple')  #cutoff 0.85
legend(0.3,0.4,       c("Model 2","Model 2b","Model 2c", "Model 2d"), lty=c(1
,1), lwd=c(2.5,2.5),col=c("red","blue","green", "purple"), pch=1, cex=0.5);
```



Model 3 Original continuous variables

Construct Model

```
selected_variables <- original_var;

selected_i <- which(colnames(training_lessOutliers) %in% selected_variables);

formula_text <- paste(response_var, "~",
                      paste(names(training)[selected_i], collapse="+"));
formula <- as.formula(formula_text);

mod_3 = glm(formula = formula , family=binomial(logit), data=training_lessOut
liers);
```

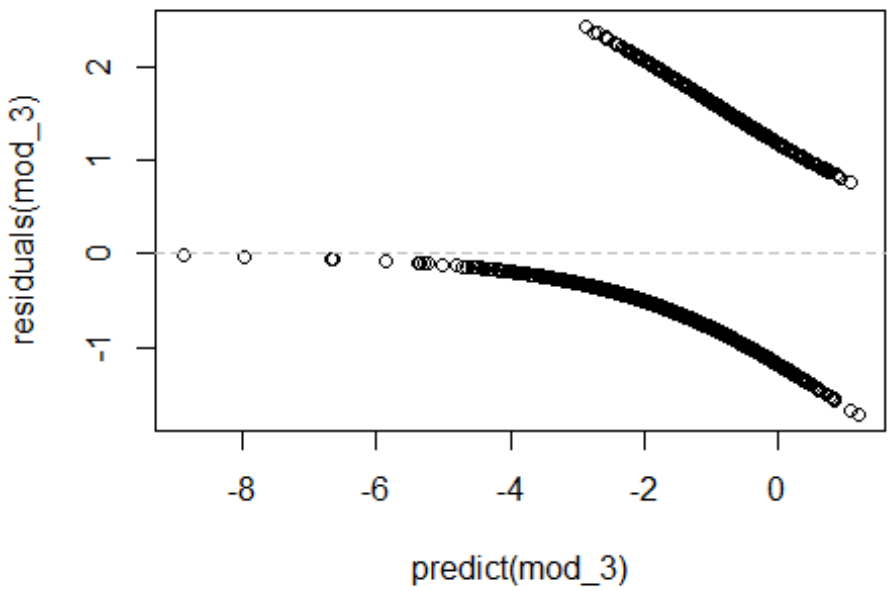
Summary

```
summary(mod_3);

##
## Call:
## glm(formula = formula, family = binomial(logit), data = training_lessOutli
ers)
##
## Deviance Residuals:
##     Min       1Q   Median       3Q      Max
## -1.7124  -0.7388  -0.5148  -0.2044   2.4239
##
```

```
## Coefficients: (1 not defined because of singularities)
##                   Estimate Std. Error z value Pr(>|z|)
## (Intercept)      8.951e+01  4.913e+01   1.822  0.06846 .
## x               -2.057e-02  2.072e-02  -0.992  0.32097
## y                2.459e-02  1.340e-02   1.834  0.06660 .
## start_speed     -1.166e+00  6.382e-01  -1.827  0.06765 .
## end_speed       -6.360e-03  1.722e-01  -0.037  0.97054
## sz_top          -3.317e-01  1.036e+00  -0.320  0.74880
## sz_bot           1.298e+00  1.077e+00   1.205  0.22827
## px               1.987e-01  6.938e-01   0.286  0.77463
## pz               1.652e+00  5.323e-01   3.103  0.00192 **
## x0              -2.991e-01  3.855e-01  -0.776  0.43785
## y0                      NA         NA      NA       NA
## z0              -1.370e+00  4.224e-01  -3.243  0.00118 **
## vx0             -7.884e-02  1.518e-01  -0.519  0.60356
## vy0             -9.135e-01  4.475e-01  -2.041  0.04120 *
## vz0             -6.350e-01  1.575e-01  -4.031 5.54e-05 ***
## ax               6.168e-03  3.448e-02   0.179  0.85803
## ay              -1.472e-01  5.504e-02  -2.674  0.00749 **
## az              -5.634e-02  7.168e-02  -0.786  0.43180
## break_y         -4.462e+00  2.074e+00  -2.151  0.03147 *
## break_length     2.084e-01  2.174e-01   0.959  0.33760
## spin_dir        -2.112e-03  5.579e-03  -0.379  0.70501
## spin_rate        7.839e-05  3.400e-04   0.231  0.81766
## trf_num_pitches  2.083e-02  1.542e-03  13.507  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 3345.5  on 3089  degrees of freedom
## Residual deviance: 2954.9  on 3068  degrees of freedom
## AIC: 2998.9
##
## Number of Fisher Scoring iterations: 5
```

Residual

```
plot(predict(mod_3),residuals(mod_3));
abline(h=0,lty=2,col="grey");
```



COefficients

```
mod_3$coefficients;
```

```
##     (Intercept)               x               y     start_speed
##    8.951037e+01   -2.056870e-02    2.458839e-02   -1.166118e+00
##       end_speed          sz_top          sz_bot              px
##   -6.360043e-03   -3.317224e-01    1.298170e+00    1.986510e-01
##              pz              x0              y0              z0
##    1.651737e+00   -2.990770e-01              NA   -1.369666e+00
##             vx0             vy0             vz0              ax
##   -7.884158e-02   -9.135098e-01   -6.349508e-01    6.167722e-03
##              ay              az         break_y    break_length
##   -1.471963e-01   -5.634498e-02   -4.461766e+00    2.084452e-01
##        spin_dir       spin_rate trf_num_pitches
##   -2.111879e-03    7.839036e-05    2.083002e-02
```

Odds Raio

```
exp(mod_3$coefficients);
```

```
##     (Intercept)               x               y     start_speed
##    7.479279e+38    9.796414e-01    1.024893e+00    3.115742e-01
##       end_speed          sz_top          sz_bot              px
##    9.936601e-01    7.176866e-01    3.662588e+00    1.219756e+00
##              pz              x0              y0              z0
##    5.216030e+00    7.415023e-01              NA    2.541918e-01
##             vx0             vy0             vz0              ax
```

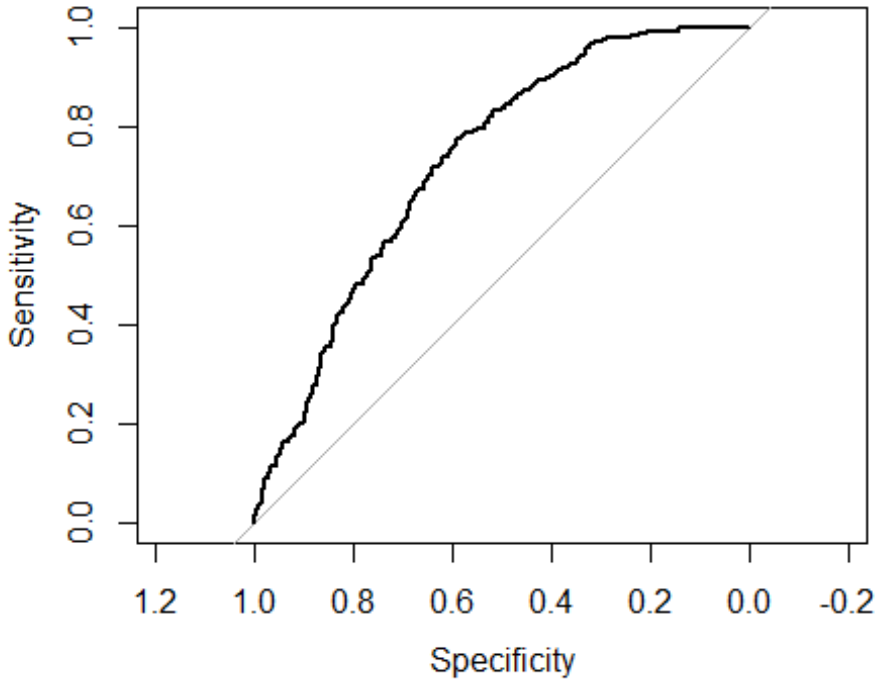
```
##    9.241863e-01    4.011139e-01    5.299615e-01    1.006187e+00
##              ay              az         break_y    break_length
##    8.631246e-01    9.452130e-01    1.154196e-02    1.231761e+00
##        spin_dir       spin_rate trf_num_pitches
##    9.978903e-01    1.000078e+00    1.021048e+00
```

Performance

```
pred <- ifelse(predict(mod_3, testing_lessOutliers, type='response') > thresh
old,  1, 0);
confusionMatrix(data=pred, reference=testing_lessOutliers$OnDL, positive='1')
;

## Confusion Matrix and Statistics
##
##           Reference
## Prediction   0   1
##          0 668 180
##          1 101  81
##
##                Accuracy : 0.7272
##                  95% CI : (0.6989, 0.7542)
##     No Information Rate : 0.7466
##     P-Value [Acc > NIR] : 0.9281
##
##                   Kappa : 0.1989
##  Mcnemar's Test P-Value : 3.27e-06
##
##             Sensitivity : 0.31034
##             Specificity : 0.86866
##          Pos Pred Value : 0.44505
##          Neg Pred Value : 0.78774
##              Prevalence : 0.25340
##          Detection Rate : 0.07864
##    Detection Prevalence : 0.17670
##       Balanced Accuracy : 0.58950
##
##        'Positive' Class : 1
##
```

ROC curve

```
prob <- predict(mod_3, testing_lessOutliers, type='response');
g3 <- roc(OnDL ~ prob, data = testing_lessOutliers);
roc.curve(testing_lessOutliers$OnDL, prob, plotit = F)

## Area under the curve (AUC): 0.729

plot(g3)
```



Model 3(b) Siginificant Continuous Variables + num pitches

Construct Model

```
selected_variables <- c("trf_num_pitches",  "start_speed", "vy0", "vz0", "bre
ak_y" );

selected_i <- which(colnames(training_lessOutliers) %in% selected_variables);

formula_text <- paste(response_var, "~",
                      paste(names(training)[selected_i], collapse="+"));
formula <- as.formula(formula_text);

mod_3b = glm(formula = formula , family=binomial(logit), data=training_lessOu
tliers);
```

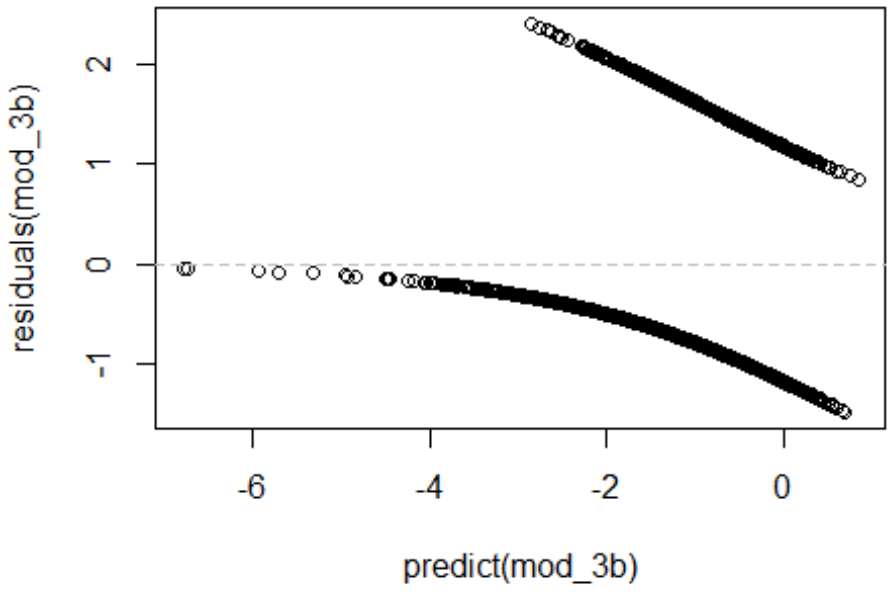
Summary

```
summary(mod_3b);

##
## Call:
## glm(formula = formula, family = binomial(logit), data = training_lessOutli
ers)
##
## Deviance Residuals:
##     Min       1Q   Median       3Q      Max
## -1.4861  -0.7449  -0.5293  -0.2556   2.4066
```

```
##
## Coefficients:
##                   Estimate Std. Error z value Pr(>|z|)
## (Intercept)       5.580861  39.454286   0.141  0.88751
## start_speed      -0.609483   0.579532  -1.052  0.29295
## vy0              -0.486067   0.397291  -1.223  0.22116
## vz0              -0.110262   0.034178  -3.226  0.00125 **
## break_y          -0.746877   1.650973  -0.452  0.65099
## trf_num_pitches   0.021762   0.001471  14.793  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 3345.5  on 3089  degrees of freedom
## Residual deviance: 3005.3  on 3084  degrees of freedom
## AIC: 3017.3
##
## Number of Fisher Scoring iterations: 5
```

Residual

```
plot(predict(mod_3b),residuals(mod_3b));
abline(h=0,lty=2,col="grey");
```



COefficients

```
mod_3b$coefficients
```

```
##     (Intercept)     start_speed             vy0             vz0
##      5.58086102     -0.60948285     -0.48606728     -0.11026238
##         break_y trf_num_pitches
##     -0.74687689      0.02176217
```

```
exp(mod_3b$coefficients);
```

```
##     (Intercept)     start_speed             vy0             vz0
##     265.2999366       0.5436319       0.6150404       0.8955991
##         break_y trf_num_pitches
##       0.4738441       1.0220007
```

Performance

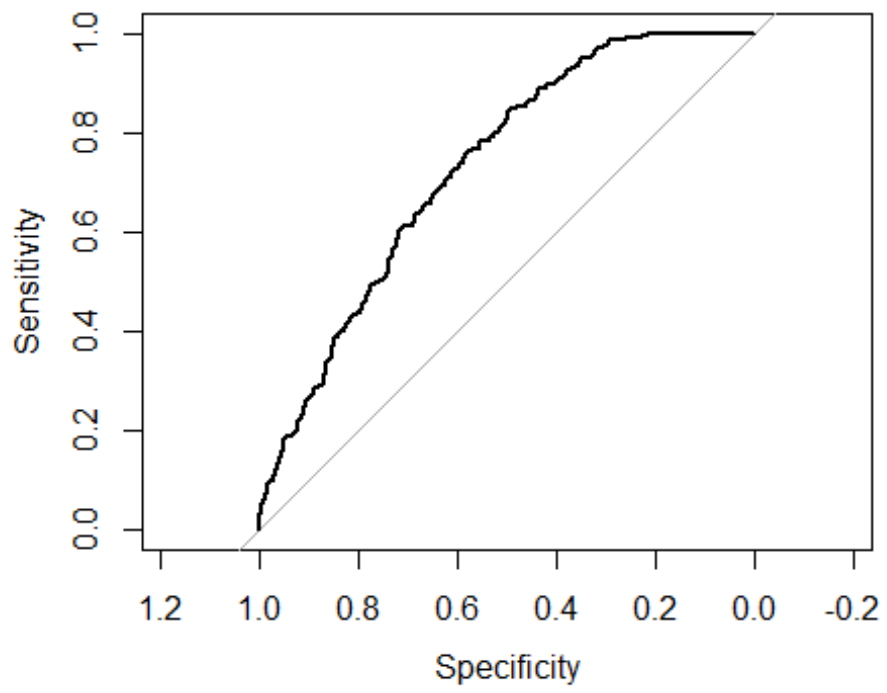
```
pred <- ifelse(predict(mod_3b, testing_lessOutliers, type='response') > thres
hold,  1, 0);
confusionMatrix(data=pred, reference=testing_lessOutliers$OnDL, positive='1')
;
```

```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction   0   1
##          0 678 187
##          1  91  74
##
##                Accuracy : 0.7301
##                  95% CI : (0.7019, 0.757)
##     No Information Rate : 0.7466
##     P-Value [Acc > NIR] : 0.8944
##
##                   Kappa : 0.188
##  Mcnemar's Test P-Value : 1.214e-08
##
##             Sensitivity : 0.28352
##             Specificity : 0.88166
##          Pos Pred Value : 0.44848
##          Neg Pred Value : 0.78382
##              Prevalence : 0.25340
##          Detection Rate : 0.07184
##    Detection Prevalence : 0.16019
##       Balanced Accuracy : 0.58259
##
##        'Positive' Class : 1
##
```

ROC curve

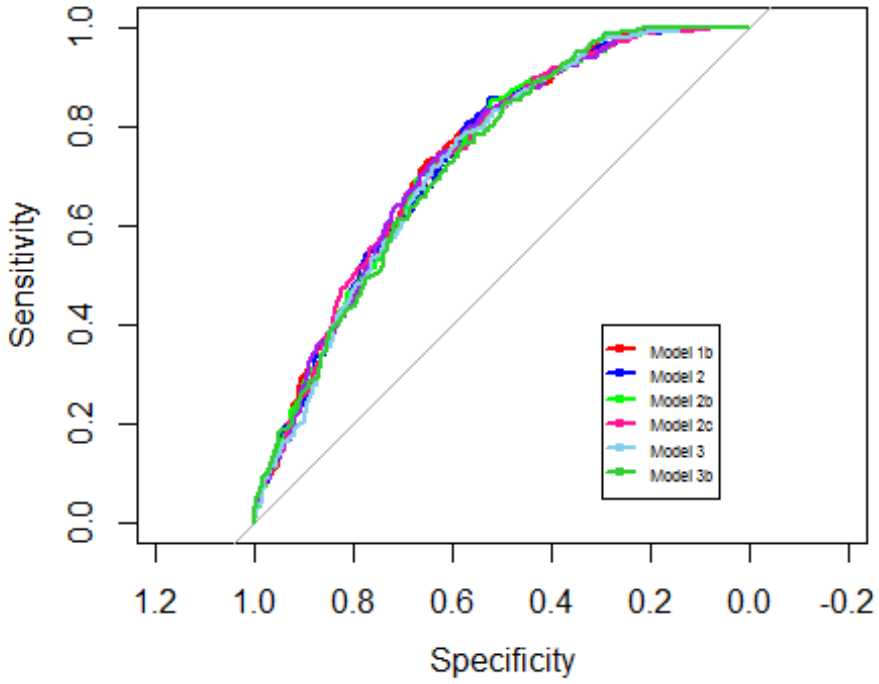
```
prob <- predict(mod_3b, testing_lessOutliers, type='response');
g3b <- roc(OnDL ~ prob, data = testing_lessOutliers);
roc.curve(testing_lessOutliers$OnDL, prob, plotit = F)
```

```
## Area under the curve (AUC): 0.729

plot(g3b)
```



Compare all models by ROC curve

```
plot(g1b, col='red');
plot(g2, col='blue', add=TRUE);
plot(g2b, col='green', add=TRUE);
plot(g2c, col='deeppink', add=TRUE);
plot(g2d, col='purple', add=TRUE);
plot(g3, col='skyblue', add=TRUE);
plot(g3b, col='limegreen', add=TRUE);

legend(0.3,0.4,       c("Model 1b","Model 2","Model 2b","Model 2c","Model 3",
"Model 3b"), lty=c(1,1), lwd=c(2.5,2.5),col=c("red","blue","green","deeppink"
,"skyblue","limegreen"), pch=1, cex=0.5);
```



Cross Validation on significant variables

```
# highlyCorDescr <- findCorrelation(m_lessOutliers, cutoff = .85);
#
# lowCorColNames <- colnames(numeric_dataset_lessOutliers[,-highlyCorDescr]);
#
#
# #filter_pitches_dl_dataset <-  filteredDescr[,-highlyCorDescr]
# #all_variables <- colnames(numeric_dataset);
# print(lowCorColNames);

selected_variables <- c("y","z0", "ay", "trf_num_FA", "trf_num_FC", "trf_num_
FF", "trf_num_FT", "trf_num_IN", "trf_num_SI");

selected_i <- which(colnames(training) %in% selected_variables);

formula_text <- paste(response_var, "~",
                      paste(names(training_lessOutliers)[selected_i], collaps
e="+"));
formula <- as.formula(formula_text);


# False positive rate
fpr <- NULL
```

```r
# False negative rate
fnr <- NULL

# True positive rate
tpr <- NULL

# True negative rate
tnr <- NULL

auc <- NULL

# Number of iterations
k <- 500

# # Initialize progress bar
# pbar <- create_progress_bar('text')
# pbar$init(k)

# Accuracy
acc <- NULL

set.seed(123)


for(i in 1:k)
{
    # Train-test splitting
    # 95% of samples -> fitting
    # 5% of samples -> testing
    smp_size <- floor(0.75 * nrow(model_dataset_lessOutliers))
    index <- sample(seq_len(nrow(model_dataset_lessOutliers)),size=smp_size)
    train <- model_dataset_lessOutliers[index, ]
    test <- model_dataset_lessOutliers[-index, ]

    # Fitting
    model <- glm(formula=formula,family=binomial,data=model_dataset_lessOutli
ers)


    # Predict results
    results_prob <- predict(model,test,type='response')

    # If prob > 0.4 then 1, else 0
    results <- ifelse(results_prob > 0.4,1,0)

    # Actual answers
    answers <- test$OnDL;
```

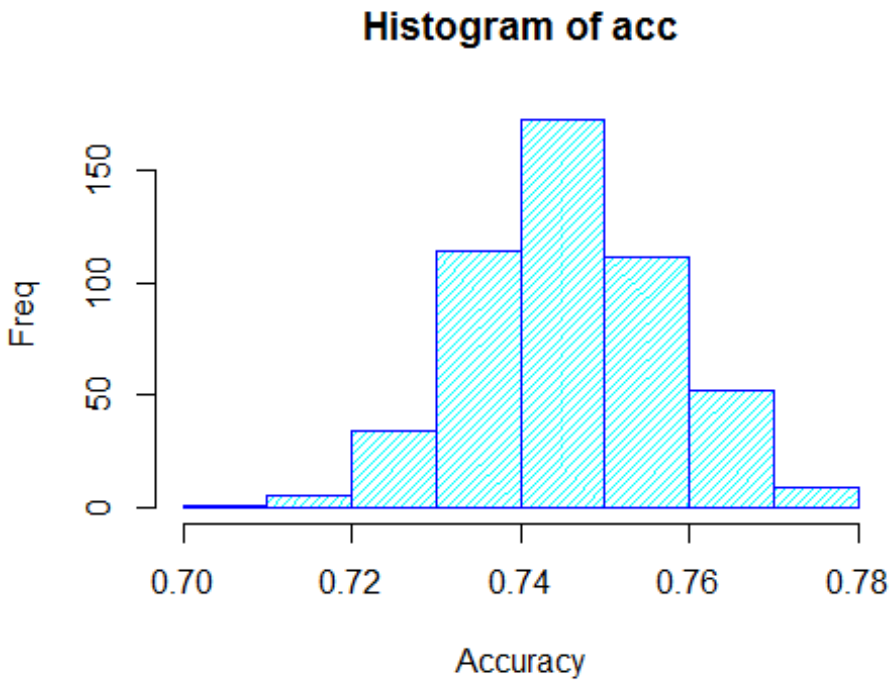
```r
    # Accuracy calculation
    misClasificError <- mean(answers != results)

    # Collecting results
    acc[i] <- 1-misClasificError

    # Confusion matrix
    cm <- confusionMatrix(data=results, reference=answers, positive='1')
    tnr[i] <- cm$table[1]/(cm$table[1]+cm$table[2])
    tpr[i] <- cm$table[4]/(cm$table[3]+cm$table[4])
    fpr[i] <- cm$table[2]/(cm$table[1]+cm$table[2])
    fnr[i] <- cm$table[3]/(cm$table[3]+cm$table[4])
    auc[i] <- roc.curve(test$OnDL, results_prob, plotit = F)$auc

    # pbar$step()
}

# Average accuracy of the model
mean(acc)
```

```
## [1] 0.7458835
```

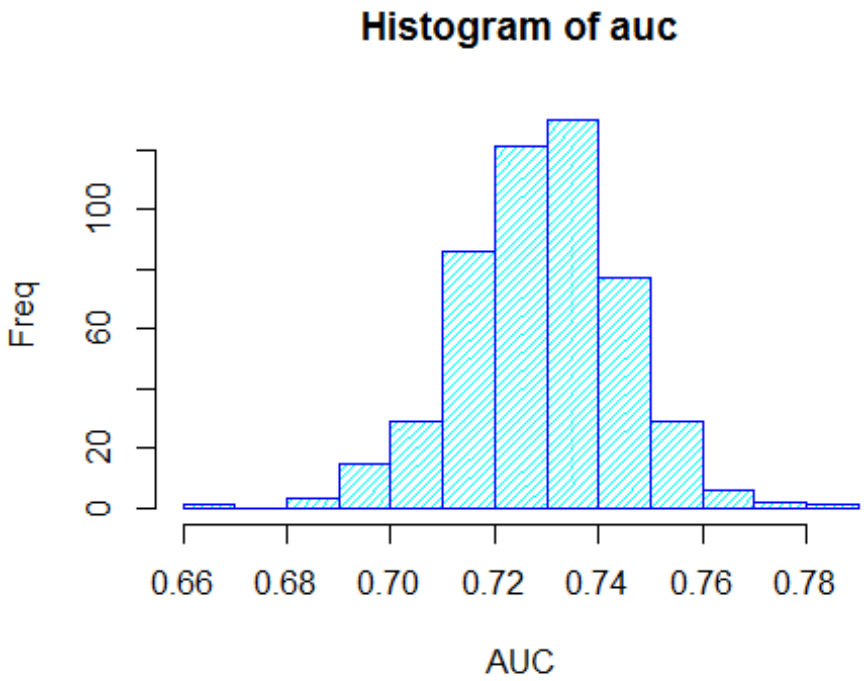
```r
# Average auc of the model
mean(auc)
```

```
## [1] 0.7289232
```

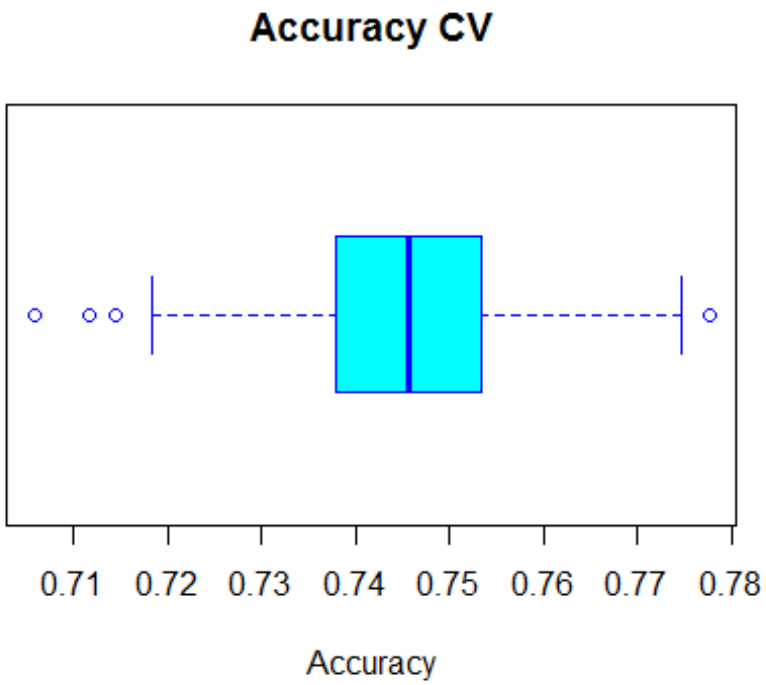
```r
# Histogram of accuracy
hist(acc,xlab='Accuracy',ylab='Freq', col='cyan',border='blue',density=30)
```



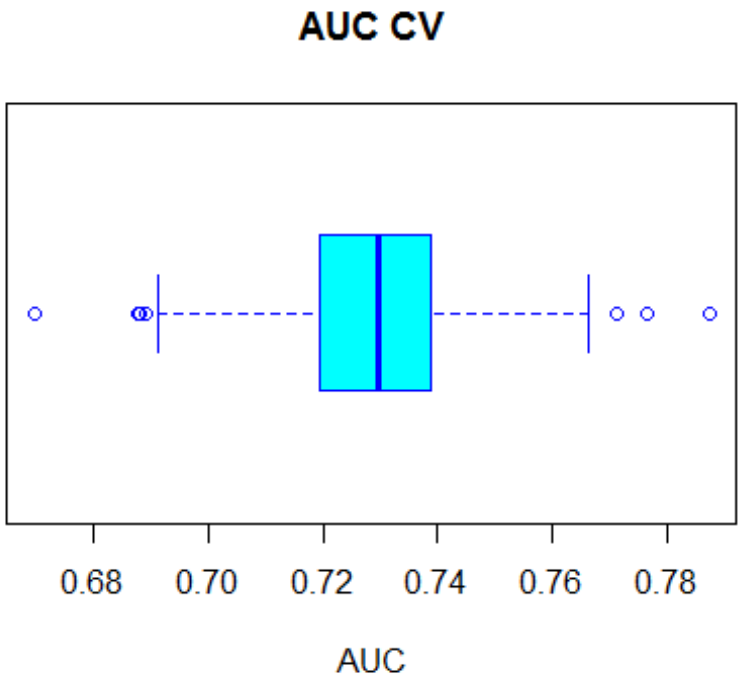

```r
# Histogram of auc
hist(auc,xlab='AUC',ylab='Freq', col='cyan',border='blue',density=30)
```



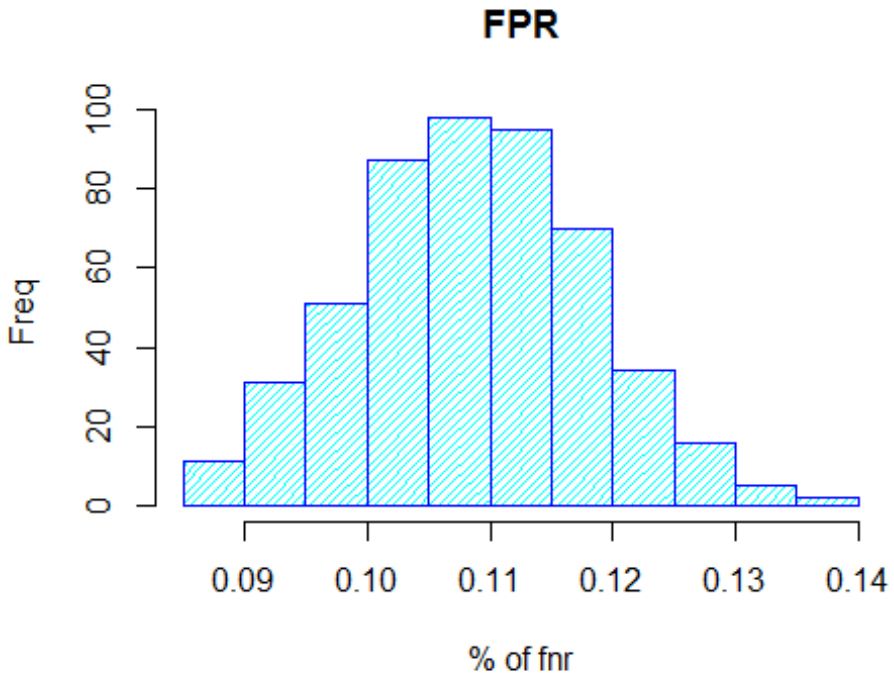
```r
# Boxplot of accuracy
boxplot(acc,col='cyan',border='blue',horizontal=T,xlab='Accuracy', main='Accu
racy CV')
```



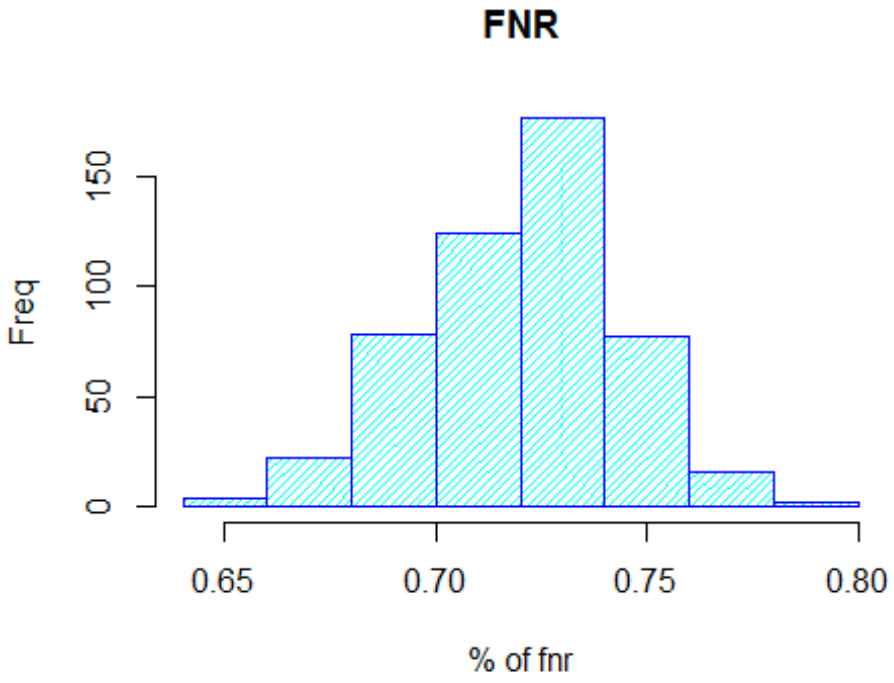

```r
# Boxplot of auc
boxplot(auc,col='cyan',border='blue',horizontal=T,xlab='AUC', main='AUC CV')
```



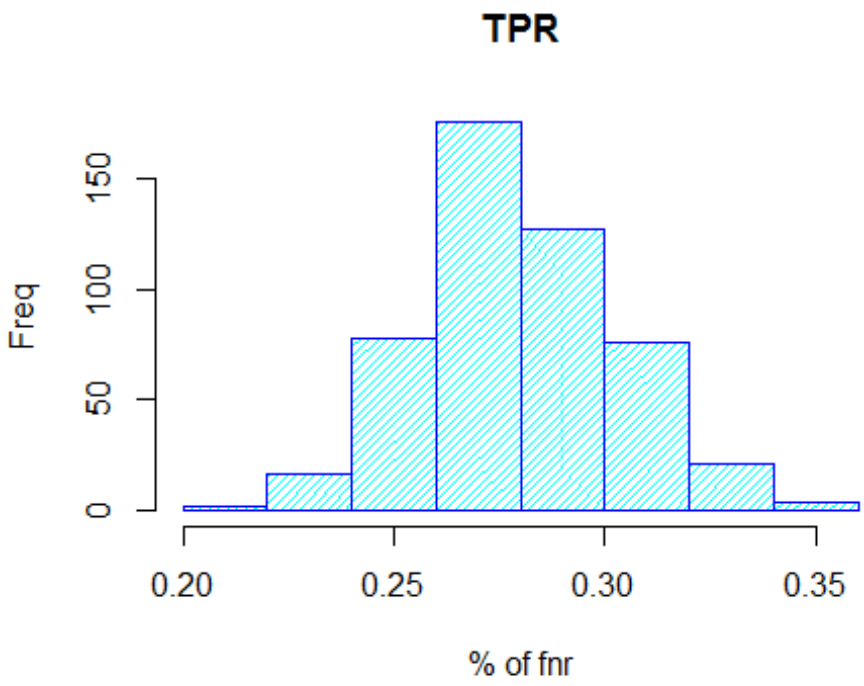

```
# Confusion matrix and plots of fpr and fnr

mean(fpr)

## [1] 0.1087389

mean(fnr)

## [1] 0.7206481

mean(tpr)

## [1] 0.2793519

mean(tnr)

## [1] 0.8912611

hist(fpr,xlab='% of fnr',ylab='Freq',main='FPR',
     col='cyan',border='blue',density=30)
```



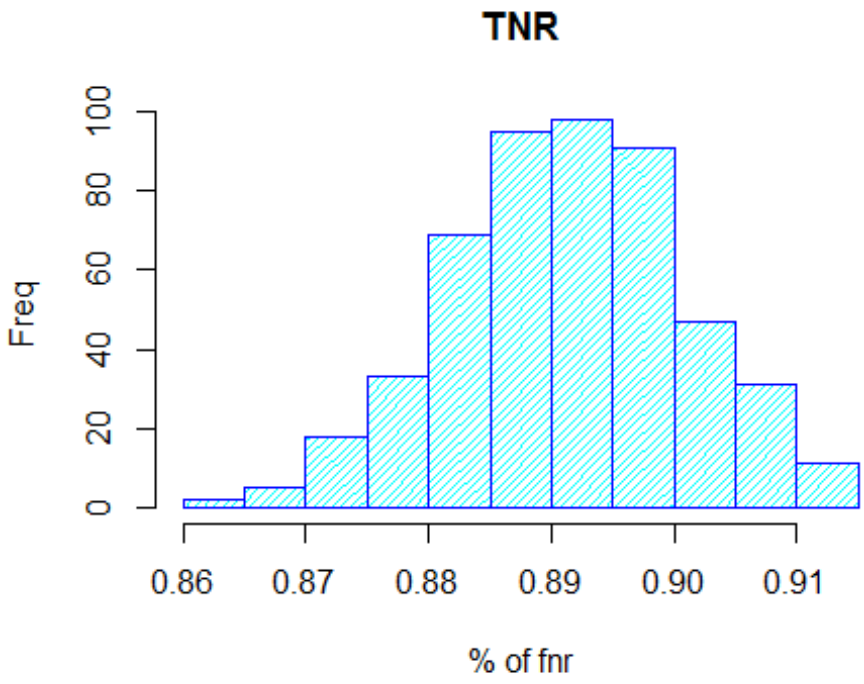

```
hist(fnr,xlab='% of fnr',ylab='Freq',main='FNR',
     col='cyan',border='blue',density=30)
```



```
hist(tpr,xlab='% of fnr',ylab='Freq',main='TPR',
     col='cyan',border='blue',density=30)
```




```
hist(tnr,xlab='% of fnr',ylab='Freq',main='TNR',
     col='cyan',border='blue',density=30)
```



Predictions for 2017

Model 2b has the highest accuracry rate.

```
pred <- (predict(mod_2b, pitches_dl_predict, type='response'))*100;

predictions <- data.frame(rsid=pitches_dl_predict$rsID, probabilty=pred);

dbhandle <- odbcDriverConnect('driver={SQL Server};server=localhost;database=
Lahman;trusted_connection=true');

query <- "SELECT retroID as rsid, nameFirst, nameLast FROM Master";

players <-sqlQuery(dbhandle, query);

predictions_players <- merge(x=predictions, y=players, by="rsid", all.x=TRUE)
;

head(predictions_players[rev(order(predictions_players$probabilty)),], 20);

##         rsid probabilty nameFirst nameLast
## 201 happj001   78.69762     J. A.     Happ
## 170 gausk001   74.92285     Kevin  Gausman
## 437 sanca006   73.32695     Aaron  Sanchez
## 348 odorj001   72.10956      Jake Odorizzi
```

```
## 341 nolar001   70.83420     Ricky  Nolasco
## 398 ray-r002   69.88841    Robbie      Ray
## 387 quinj001   66.97850      Jose Quintana
## 241 jimeu001   65.75076    Ubaldo  Jimenez
## 276 lestj001   65.68297       Jon   Lester
## 371 perem004   65.51329    Martin    Perez
## 379 pinem001   65.34702   Michael   Pineda
## 370 peraw001   64.67090      Wily  Peralta
## 381 porcr001   64.59890      Rick Porcello
## 15  arrij001   64.59393      Jake  Arrieta
## 199 hammj002   64.19380     Jason   Hammel
## 509 walkt004   64.17469   Taijuan   Walker
## 81  chatt001   63.70163     Tyler Chatwood
## 252 kenni001   62.88287       Ian  Kennedy
## 472 strom001   62.70291    Marcus  Stroman
## 266 lackj001   61.72387      John   Lackey
```