Cincinnati Reds

Assessment 2.5

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```
#Sam Rizzuto
#Cincinnati Reds
#Technical Assessment: 2.5
#6 February 2022


#load libraries
library(dplyr)
library(mgcv)
library(parallel)
library(visreg)
library(ggplot2)
library(randomForest)
library(e1071)
library(caret)
library(flexclust)
library(factoextra)
library(knitr)

#set working directory
setwd("~/Desktop/22-ds")

#load in datasets
trainDF <- read.csv("train.csv")
testDF <- read.csv("test.csv")



#backward tracking hit velo

#distribute grouping each 3 vars based on pitch type from k means and TB hit from slg and
# says this is hr launch angle pulls them randomly runs 1000 times says this is LA on tet
#first randomize tb
#randomize again
#take avg
# smallSmall <- trainDF[1:5,12:44]
#
# store2 <- list()
# for (i in 1:nrow(smallSmall)) {
#   storeTest <- sample(smallSmall[i,30:33], 1, prob = abs(c(smallSmall[i,30], smallSmall[i,31], smallSmall[i,
#   store2[[i]] <- storeTest
# }
# store2
#then calcluate probability of the 5 outcomes


# trainDF <- trainDF %>% mutate(swingSpeed = EXIT_SPEED - (0.2 * trainDF$RELEASE_SPEED) / (1 + 0.2))
# newDF <- trainDF %>% group_by(BATTER_UID) %>% summarise(avgSS = mean(swingSpeed),
#                                                          n = n())
# newDF %>% arrange(desc(avgSS))
#
# hist(newDF$avgSS)
#
# #0,2 wooden, avg 70mph blast motion
# exitVeloFormula <- (0.2 * trainDF$RELEASE_SPEED) + (1 + 0.2)*runif(nrow(trainDF), min = 40, max = 80)
# summary(exitVeloFormula)
# round(asin(trainDF$PLATE_X / exitVeloFormula*(21.922)),3)
```

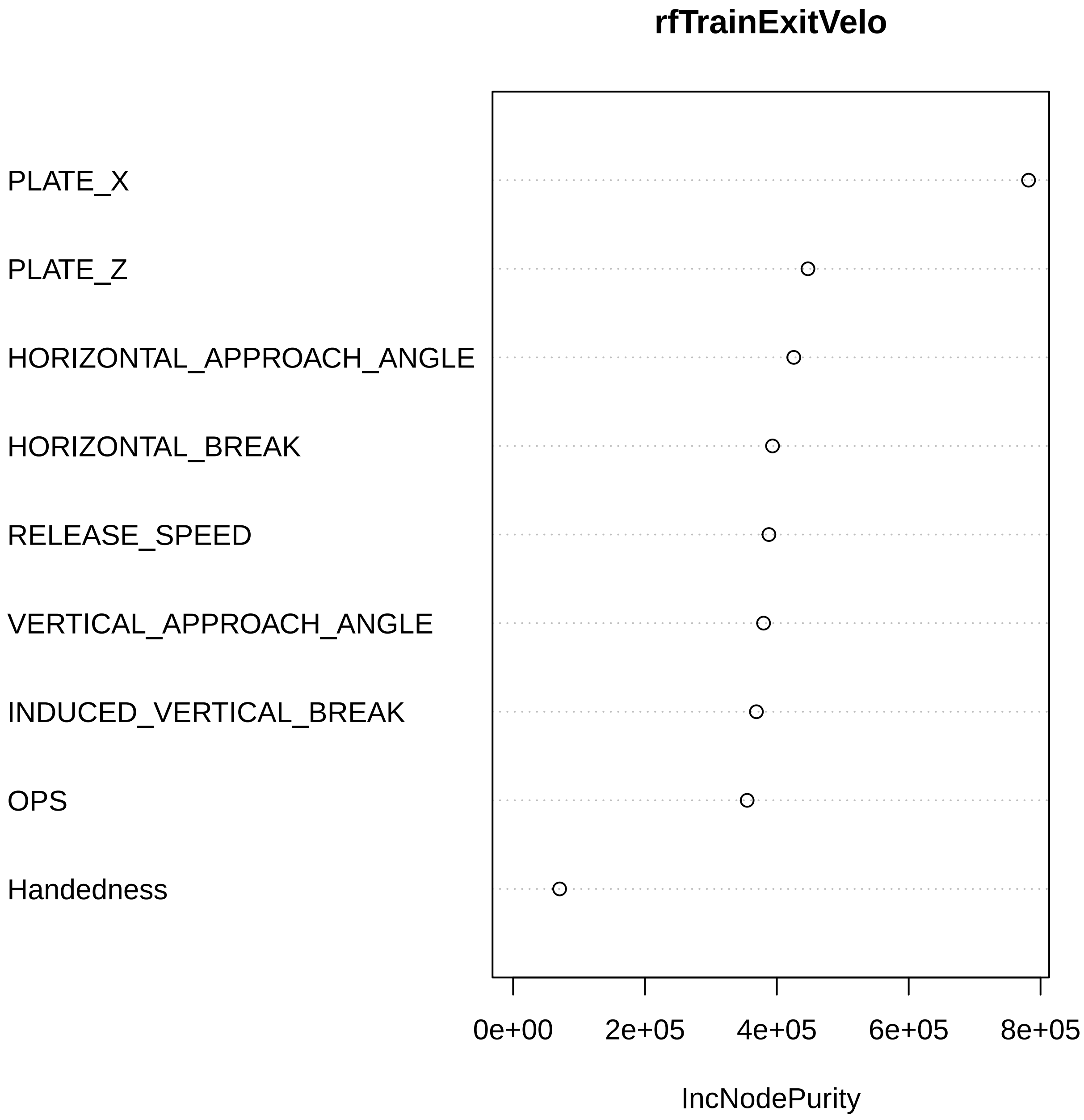
```r
#pitchers can predict launch angle the most
#not exit velo or spray angle

#slash line

#vaa down in zone, can predicr launch angle is gonna be low

#cant predict exit velo


#deviance explained, t value p val

#gam better for predicting constant

#same hand or diff
#low exit velo if same

######################Filtering Data and Removing Outliers through IQR
Q1_Angle <- quantile(trainDF$ANGLE, .25)
Q3_Angle <- quantile(trainDF$ANGLE, .75)
IQR_Angle <- IQR(trainDF$ANGLE)

Q1_EXIT_SPEED <- quantile(trainDF$EXIT_SPEED, .25)
Q3_EXIT_SPEED <- quantile(trainDF$EXIT_SPEED, .75)
IQR_EXIT_SPEED <- IQR(trainDF$EXIT_SPEED)

Q1_DIRECTION <- quantile(trainDF$DIRECTION, .25)
Q3_DIRECTION <- quantile(trainDF$DIRECTION, .75)
IQR_DIRECTION <- IQR(trainDF$DIRECTION)

Q1_ReleaseSpeed <- quantile(trainDF$RELEASE_SPEED, .25)
Q3_ReleaseSpeed <- quantile(trainDF$RELEASE_SPEED, .75)
IQR_ReleaseSpeed <- IQR(trainDF$RELEASE_SPEED)

Q1_PlateX <- quantile(trainDF$PLATE_X, .25)
Q3_PlateX <- quantile(trainDF$PLATE_X, .75)
IQR_PlateX <- IQR(trainDF$PLATE_X)

Q1_PlateZ <- quantile(trainDF$PLATE_Z, .25)
Q3_PlateZ <- quantile(trainDF$PLATE_Z, .75)
IQR_PlateZ <- IQR(trainDF$PLATE_Z)

Q1_InducedVertBreak <- quantile(trainDF$INDUCED_VERTICAL_BREAK, .25)
Q3_InducedVertBreak <- quantile(trainDF$INDUCED_VERTICAL_BREAK, .75)
IQR_InducedVertBreak <- IQR(trainDF$INDUCED_VERTICAL_BREAK)

Q1_HorizontalBreak <- quantile(trainDF$HORIZONTAL_BREAK, .25)
Q3_HorizontalBreak <- quantile(trainDF$HORIZONTAL_BREAK, .75)
IQR_HorizontalBreak <- IQR(trainDF$HORIZONTAL_BREAK)

Q1_VertApproachAngle <- quantile(trainDF$VERTICAL_APPROACH_ANGLE, .25)
Q3_VertApproachAngle <- quantile(trainDF$VERTICAL_APPROACH_ANGLE, .75)
IQR_VertApproachAngle <- IQR(trainDF$VERTICAL_APPROACH_ANGLE)

Q1_HorizApproachAngle <- quantile(trainDF$HORIZONTAL_APPROACH_ANGLE, .25)
Q3_HorizApproachAngle <- quantile(trainDF$HORIZONTAL_APPROACH_ANGLE, .75)
IQR_HorizApproachAngle <- IQR(trainDF$HORIZONTAL_APPROACH_ANGLE)
```

```r
trainDF <- subset(trainDF, trainDF$ANGLE > (Q1_Angle - 1.5*IQR_Angle) & trainDF$ANGLE < (Q3_Angle + 1.5*IQR_An
trainDF <- subset(trainDF, trainDF$EXIT_SPEED > (Q1_EXIT_SPEED - 1.5*IQR_EXIT_SPEED) & trainDF$EXIT_SPEED < (Q
trainDF <- subset(trainDF, trainDF$DIRECTION > (Q1_DIRECTION - 1.5*IQR_DIRECTION) & trainDF$DIRECTION < (Q3_DI

trainDF <- subset(trainDF, trainDF$RELEASE_SPEED > (Q1_ReleaseSpeed - 1.5*IQR_ReleaseSpeed) & trainDF$RELEASE_
trainDF <- subset(trainDF, trainDF$PLATE_X > (Q1_PlateX - 1.5*IQR_PlateX) & trainDF$PLATE_X < (Q3_PlateX + 1.5
trainDF <- subset(trainDF, trainDF$PLATE_Z > (Q1_PlateZ - 1.5*IQR_PlateZ) & trainDF$PLATE_Z < (Q3_PlateZ + 1.5
trainDF <- subset(trainDF, trainDF$INDUCED_VERTICAL_BREAK > (Q1_InducedVertBreak - 1.5*IQR_InducedVertBreak) &
trainDF <- subset(trainDF, trainDF$HORIZONTAL_BREAK > (Q1_HorizontalBreak - 1.5*IQR_HorizontalBreak) & trainDF
trainDF <- subset(trainDF, trainDF$VERTICAL_APPROACH_ANGLE > (Q1_VertApproachAngle - 1.5*IQR_VertApproachAngle
trainDF <- subset(trainDF, trainDF$HORIZONTAL_APPROACH_ANGLE > (Q1_HorizApproachAngle - 1.5*IQR_HorizApproachA

#disregard strikeouts, hbp, walks
trainDF <- trainDF %>% filter(PITCH_RESULT_KEY == "InPlay")
#goes from original 26417 rows to 24510 after cleaning

summary(trainDF)
```

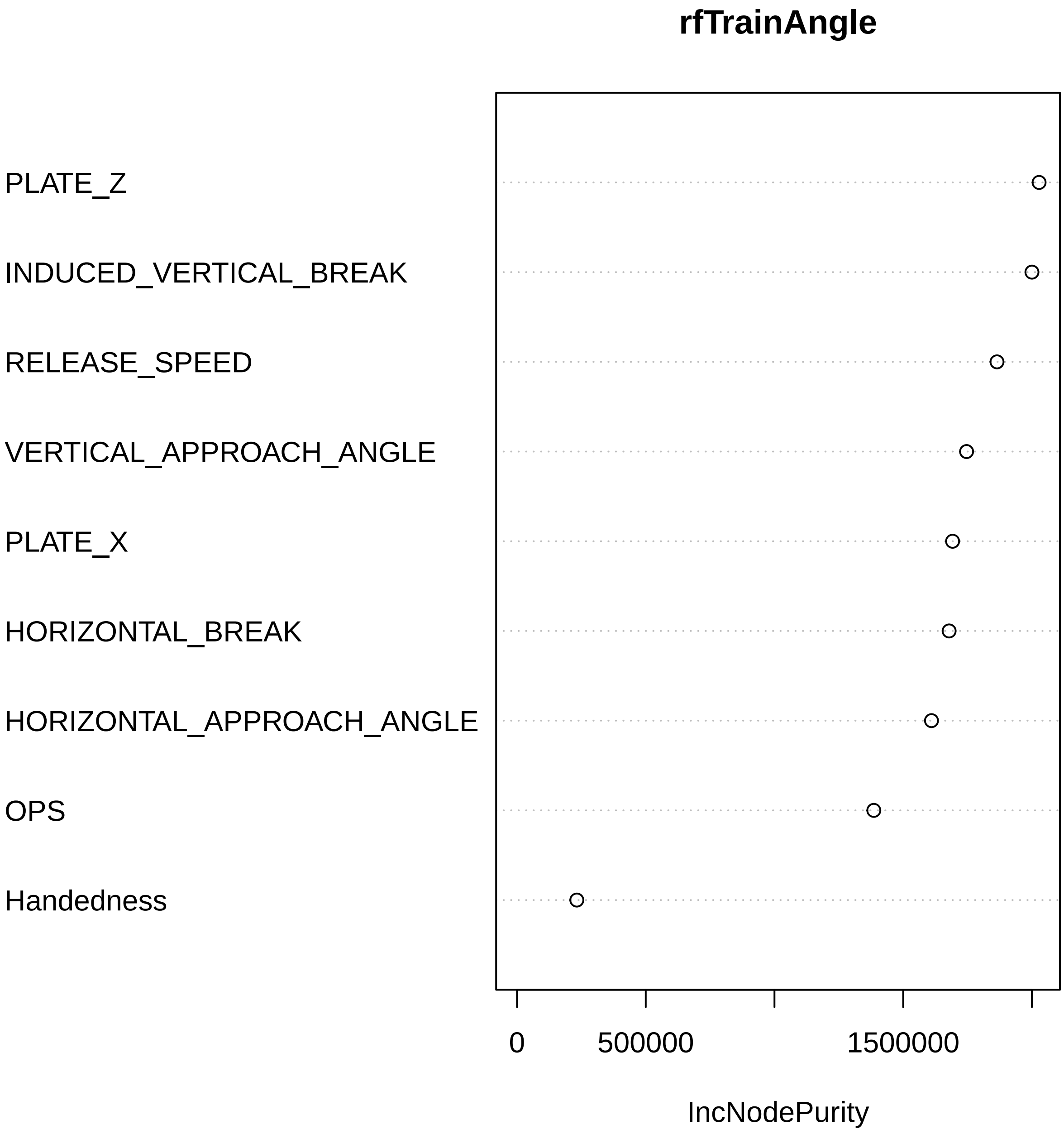
```
   BATTER_UID          AVG               OBP               SLG        
 Min.   :  2.00   Min.   :0.1850   Min.   :0.2570   Min.   :0.2880  
 1st Qu.: 36.00   1st Qu.:0.2523   1st Qu.:0.3210   1st Qu.:0.3770  
 Median : 77.00   Median :0.2670   Median :0.3380   Median :0.4125  
 Mean   : 76.96   Mean   :0.2665   Mean   :0.3387   Mean   :0.4216  
 3rd Qu.:118.00   3rd Qu.:0.2860   3rd Qu.:0.3580   3rd Qu.:0.4545  
 Max.   :157.00   Max.   :0.3330   Max.   :0.4440   Max.   :0.6130  
   VENUE_KEY         OUTS             BALLS          STRIKES     
 Min.   :2528   Min.   :0.0000   Min.   :0.000   Min.   :0.000  
 1st Qu.:2745   1st Qu.:0.0000   1st Qu.:0.000   1st Qu.:0.000  
 Median :2843   Median :1.0000   Median :1.000   Median :1.000  
 Mean   :3510   Mean   :0.9632   Mean   :1.106   Mean   :1.076  
 3rd Qu.:4669   3rd Qu.:2.0000   3rd Qu.:2.000   3rd Qu.:2.000  
 Max.   :5472   Max.   :2.0000   Max.   :4.000   Max.   :2.000  
   BATS_LEFT       THROWS_LEFT      PITCH_NUMBER    RELEASE_SPEED   
 Min.   :0.0000   Min.   :0.0000   Min.   : 1.000   Min.   : 70.69  
 1st Qu.:0.0000   1st Qu.:0.0000   1st Qu.: 2.000   1st Qu.: 84.41  
 Median :0.0000   Median :0.0000   Median : 3.000   Median : 89.41  
 Mean   :0.4092   Mean   :0.2502   Mean   : 3.369   Mean   : 88.48  
 3rd Qu.:1.0000   3rd Qu.:1.0000   3rd Qu.: 5.000   3rd Qu.: 92.82  
 Max.   :1.0000   Max.   :1.0000   Max.   :14.000   Max.   :102.25  
    PLATE_X              PLATE_Z       INDUCED_VERTICAL_BREAK HORIZONTAL_BREAK
 Min.   :-1.526430   Min.   :0.8597   Min.   :-14.609        Min.   :-26.017 
 1st Qu.:-0.379685   1st Qu.:2.0195   1st Qu.:  3.729        1st Qu.:-10.609 
 Median : 0.004996   Median :2.3900   Median :  9.928        Median : -3.428 
 Mean   :-0.001254   Mean   :2.3965   Mean   :  8.933        Mean   : -2.280 
 3rd Qu.: 0.372303   3rd Qu.:2.7676   3rd Qu.: 15.245        3rd Qu.:  5.561 
 Max.   : 1.518160   Max.   :3.9181   Max.   : 32.694        Max.   : 25.943 
 VERTICAL_APPROACH_ANGLE HORIZONTAL_APPROACH_ANGLE   EXIT_SPEED    
 Min.   :-10.290         Min.   :-4.1542           Min.   : 51.29  
 1st Qu.: -7.252         1st Qu.:-0.3791           1st Qu.: 81.23  
 Median : -6.208         Median : 0.8640           Median : 91.49  
 Mean   : -6.371         Mean   : 0.7543           Mean   : 89.32  
 3rd Qu.: -5.376         3rd Qu.: 2.0378           3rd Qu.: 98.98  
 Max.   : -2.787         Max.   : 5.7566           Max.   :118.64  
     ANGLE            DIRECTION        EVENT_RESULT_KEY   PITCH_RESULT_KEY  
 Min.   :-58.917   Min.   :-68.576   Length:24510       Length:24510      
 1st Qu.: -4.377   1st Qu.:-17.733   Class :character   Class :character  
 Median : 13.619   Median : -1.480   Mode  :character   Mode  :character  
 Mean   : 13.177   Mean   : -1.374                                        
 3rd Qu.: 29.796   3rd Qu.: 14.795                                        
 Max.   : 82.393   Max.   : 65.317                                        
```

```
       PA          X1B               X2B                X3B          
 Min.   :1   Min.   :0.0000   Min.   :0.00000   Min.   :0.000000  
 1st Qu.:1   1st Qu.:0.0000   1st Qu.:0.00000   1st Qu.:0.000000  
 Median :1   Median :0.0000   Median :0.00000   Median :0.000000  
 Mean   :1   Mean   :0.2225   Mean   :0.08156   Mean   :0.008772  
 3rd Qu.:1   3rd Qu.:0.0000   3rd Qu.:0.00000   3rd Qu.:0.000000  
 Max.   :1   Max.   :1.0000   Max.   :1.00000   Max.   :1.000000  
       HR         
 Min.   :0.00000  
 1st Qu.:0.00000  
 Median :0.00000  
 Mean   :0.05859  
 3rd Qu.:0.00000  
 Max.   :1.00000  
```

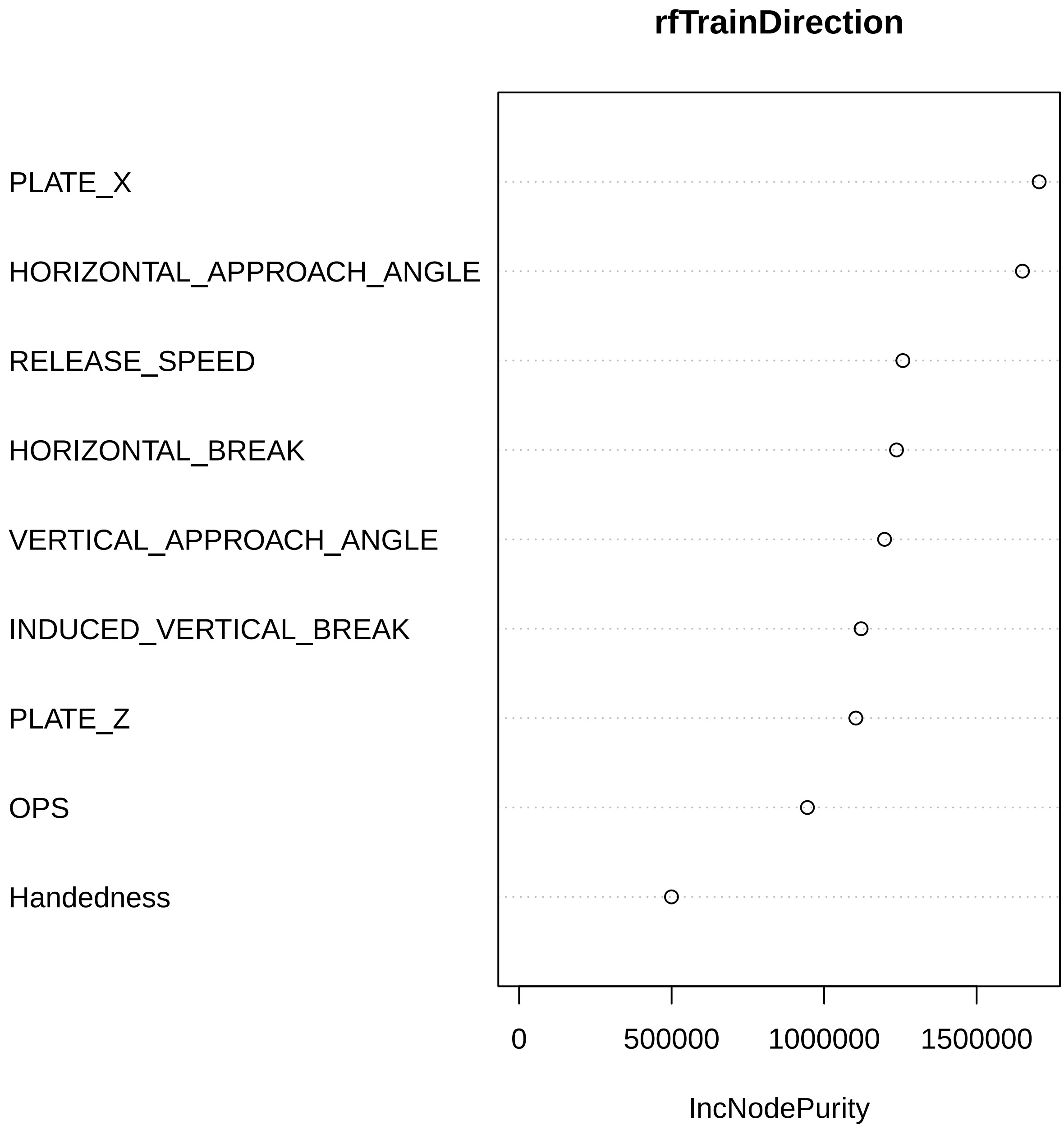
```
######################

trainDF <- trainDF %>% mutate(OPS = OBP + SLG)
testDF <- testDF %>% mutate(OPS = OBP + SLG)
trainDF <- trainDF %>% mutate(Handedness = if_else(THROWS_LEFT == BATS_LEFT, 0, 1))
testDF <- testDF %>% mutate(Handedness = if_else(THROWS_LEFT == BATS_LEFT, 0, 1))

######################Random Forest model
#running random forest on 3 prediction variables
rfTrainExitVelo <- randomForest(EXIT_SPEED ~ RELEASE_SPEED + PLATE_X + PLATE_Z +
                                  INDUCED_VERTICAL_BREAK + HORIZONTAL_BREAK +
                                  VERTICAL_APPROACH_ANGLE + HORIZONTAL_APPROACH_ANGLE +
                                  OPS + Handedness, data = trainDF)
rfTrainAngle <- randomForest(ANGLE ~ RELEASE_SPEED + PLATE_X + PLATE_Z +
                               INDUCED_VERTICAL_BREAK + HORIZONTAL_BREAK +
                               VERTICAL_APPROACH_ANGLE + HORIZONTAL_APPROACH_ANGLE +
                               OPS + Handedness, data = trainDF)
rfTrainDirection <- randomForest(DIRECTION ~ RELEASE_SPEED + PLATE_X + PLATE_Z +
                                   INDUCED_VERTICAL_BREAK + HORIZONTAL_BREAK +
                                   VERTICAL_APPROACH_ANGLE + HORIZONTAL_APPROACH_ANGLE +
                                   OPS + Handedness, data = trainDF)
#viewing importance plots of each model type to determine most significant vars in model
varImpPlot(rfTrainExitVelo) #drop handedness
```



```
varImpPlot(rfTrainAngle) #drop ops, handedness
```



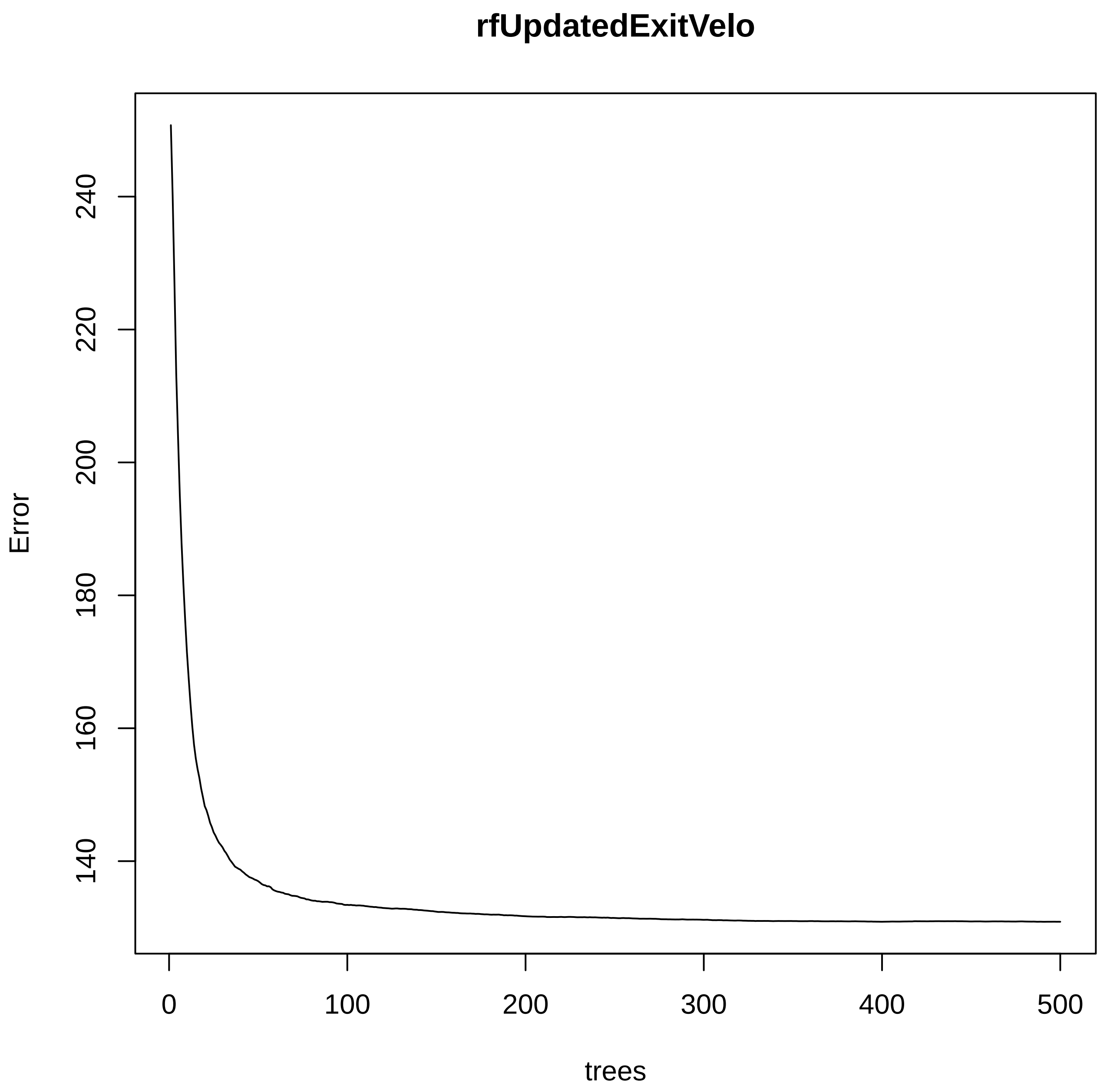
```
varImpPlot(rfTrainDirection) #drop handedness
```



```
#choose first grouping vars
rfUpdatedExitVelo <- randomForest(EXIT_SPEED ~ PLATE_X + PLATE_Z + HORIZONTAL_APPROACH_ANGLE +
                                    HORIZONTAL_BREAK + RELEASE_SPEED +
                                    VERTICAL_APPROACH_ANGLE + INDUCED_VERTICAL_BREAK + OPS, data = trainDF)
importance(rfUpdatedExitVelo) #importance vars of rf exit velo model
```

```
                          IncNodePurity
PLATE_X                        762906.9
PLATE_Z                        443837.5
HORIZONTAL_APPROACH_ANGLE      431196.4
HORIZONTAL_BREAK               395821.7
RELEASE_SPEED                  396771.6
VERTICAL_APPROACH_ANGLE        391335.9
INDUCED_VERTICAL_BREAK         382291.6
OPS                            364110.7
```

```
plot(rfUpdatedExitVelo) #error of rf exit velo model
```



```
rfUpdatedAngle <- randomForest(ANGLE ~ PLATE_Z + INDUCED_VERTICAL_BREAK + RELEASE_SPEED + VERTICAL_APPROACH_AN
                                PLATE_X + HORIZONTAL_BREAK + HORIZONTAL_APPROACH_ANGLE , data = trainDF)

rfUpdatedDirection <- randomForest(DIRECTION ~  PLATE_X + HORIZONTAL_APPROACH_ANGLE + RELEASE_SPEED +
                                     HORIZONTAL_BREAK + VERTICAL_APPROACH_ANGLE +
                                     INDUCED_VERTICAL_BREAK + PLATE_Z + OPS, data = trainDF)



#plot randomForest results back in trainDF
trainDF <- trainDF %>%
  mutate(exitVelo_RF = round(predict(rfUpdatedExitVelo, newdata = .),3))
trainDF <- trainDF %>%
  mutate(angle_RF = round(predict(rfUpdatedAngle, newdata = .),3))
trainDF <- trainDF %>%
  mutate(direction_RF = round(predict(rfUpdatedDirection, newdata = .),3))

######################SVM model
#running svm on exit velo
svmExitVelo <- svm(EXIT_SPEED ~ RELEASE_SPEED + PLATE_X + PLATE_Z +
                       INDUCED_VERTICAL_BREAK + HORIZONTAL_BREAK +
                       VERTICAL_APPROACH_ANGLE + HORIZONTAL_APPROACH_ANGLE +
                       OPS + Handedness, data = trainDF, cost = 100, gamma = 1)
#removing predictor variable of exit velo
svmExitVelo_Pred <- round(predict(svmExitVelo, trainDF[,-19]), 3)
#add svm exit velo into training df
trainDF <- trainDF %>% mutate(exitVelo_SVM = svmExitVelo_Pred)



#running svm on angle
svmAngle <- svm(ANGLE ~ RELEASE_SPEED + PLATE_X + PLATE_Z +
                  INDUCED_VERTICAL_BREAK + HORIZONTAL_BREAK +
                  VERTICAL_APPROACH_ANGLE + HORIZONTAL_APPROACH_ANGLE +
                  OPS + Handedness, data = trainDF, cost = 100, gamma = 1)
#removing predictor variable of angle
svmAngle_Pred <- round(predict(svmAngle, trainDF[,-20]), 3)
#adding prob of angle into training df
trainDF <- trainDF %>% mutate(angle_SVM = svmAngle_Pred)



#running svm model on direction
svmDirection <- svm(DIRECTION ~ RELEASE_SPEED + PLATE_X + PLATE_Z +
                      INDUCED_VERTICAL_BREAK + HORIZONTAL_BREAK +
                      VERTICAL_APPROACH_ANGLE + HORIZONTAL_APPROACH_ANGLE +
                      OPS + Handedness, data = trainDF, cost = 100, gamma = 1)
#removing predictor variable of direction
svmDirection_Pred <- round(predict(svmDirection, trainDF[,-21]), 3)
#adding direction into training df
trainDF <- trainDF %>% mutate(direction_SVM = svmDirection_Pred)

######################generalized additive model to include most important variables in training dataset
options(mc.cores = parallel::detectCores())#run model in parallel

gam_EV <- bam(EXIT_SPEED ~ RELEASE_SPEED + PLATE_X + PLATE_Z + INDUCED_VERTICAL_BREAK +
              HORIZONTAL_BREAK + VERTICAL_APPROACH_ANGLE + HORIZONTAL_APPROACH_ANGLE + OPS + Handedness,
            data = trainDF, family = gaussian, method = "GCV.Cp")
summary(gam_EV) #drop platex, platez, vert approach angle

Family: gaussian
Link function: identity

Formula:
EXIT_SPEED ~ RELEASE_SPEED + PLATE_X + PLATE_Z + INDUCED_VERTICAL_BREAK +
    HORIZONTAL_BREAK + VERTICAL_APPROACH_ANGLE + HORIZONTAL_APPROACH_ANGLE +
    OPS + Handedness

Parametric coefficients:
                          Estimate Std. Error t value Pr(>|t|)
(Intercept)               62.49285    3.30876  18.887  < 2e-16 ***
RELEASE_SPEED              0.18434    0.02492   7.398 1.42e-13 ***
PLATE_X                    0.07433    0.17082   0.435   0.6635
PLATE_Z                    0.06586    0.21768   0.303   0.7622
INDUCED_VERTICAL_BREAK     0.03296    0.01815   1.816   0.0694 .
HORIZONTAL_BREAK          -0.02235    0.00887  -2.520   0.0118 *
VERTICAL_APPROACH_ANGLE   -0.06991    0.15320  -0.456   0.6482
HORIZONTAL_APPROACH_ANGLE -0.08299    0.04914  -1.689   0.0912 .
OPS                       12.22985    0.99085  12.343  < 2e-16 ***
Handedness                 0.66970    0.16287   4.112 3.94e-05 ***
```

```
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1


R-sq.(adj) =  0.0163   Deviance explained = 1.67%
GCV = 154.34  Scale est. = 154.28    n = 24510

gam_EV_Upd <- bam(EXIT_SPEED ~ RELEASE_SPEED + INDUCED_VERTICAL_BREAK +
                HORIZONTAL_BREAK + HORIZONTAL_APPROACH_ANGLE + OPS + Handedness,
              data = trainDF, family = gaussian, method = "GCV.Cp")

gam_Ang <- bam(ANGLE ~ RELEASE_SPEED + PLATE_X + PLATE_Z + INDUCED_VERTICAL_BREAK +
              HORIZONTAL_BREAK + VERTICAL_APPROACH_ANGLE + HORIZONTAL_APPROACH_ANGLE + OPS + Handedness,
            data = trainDF, family = gaussian, method = "GCV.Cp")
summary(gam_Ang) #no drop

Family: gaussian
Link function: identity

Formula:
ANGLE ~ RELEASE_SPEED + PLATE_X + PLATE_Z + INDUCED_VERTICAL_BREAK +
    HORIZONTAL_BREAK + VERTICAL_APPROACH_ANGLE + HORIZONTAL_APPROACH_ANGLE +
    OPS + Handedness

Parametric coefficients:
                          Estimate Std. Error t value Pr(>|t|)
(Intercept)               80.24128    6.36217  12.612  < 2e-16 ***
RELEASE_SPEED             -1.09556    0.04791 -22.867  < 2e-16 ***
PLATE_X                   -1.21579    0.32846  -3.702 0.000215 ***
PLATE_Z                    8.14747    0.41856  19.466  < 2e-16 ***
INDUCED_VERTICAL_BREAK     0.78607    0.03490  22.522  < 2e-16 ***
HORIZONTAL_BREAK           0.06256    0.01706   3.668 0.000245 ***
VERTICAL_APPROACH_ANGLE    0.55608    0.29459   1.888 0.059084 .
HORIZONTAL_APPROACH_ANGLE  0.75715    0.09448   8.014 1.16e-15 ***
OPS                        7.73271    1.90523   4.059 4.95e-05 ***
Handedness                 1.10150    0.31318   3.517 0.000437 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1


R-sq.(adj) =  0.0814   Deviance explained = 8.17%
GCV = 570.63  Scale est. = 570.4     n = 24510

gam_Ang_Upd <- gam_Ang

gam_Dir <- bam(DIRECTION ~ RELEASE_SPEED + PLATE_X + PLATE_Z + INDUCED_VERTICAL_BREAK +
              HORIZONTAL_BREAK + VERTICAL_APPROACH_ANGLE + HORIZONTAL_APPROACH_ANGLE + OPS + Handedness,
            data = trainDF, family = gaussian, method = "GCV.Cp")
summary(gam_Dir) #drop platez

Family: gaussian
Link function: identity

Formula:
DIRECTION ~ RELEASE_SPEED + PLATE_X + PLATE_Z + INDUCED_VERTICAL_BREAK +
    HORIZONTAL_BREAK + VERTICAL_APPROACH_ANGLE + HORIZONTAL_APPROACH_ANGLE +
    OPS + Handedness

Parametric coefficients:
```

```
                          Estimate Std. Error t value Pr(>|t|)
(Intercept)               -8.41722    5.44751  -1.545 0.122323
RELEASE_SPEED              0.14499    0.04102   3.534 0.000409 ***
PLATE_X                    9.80451    0.28124  34.862  < 2e-16 ***
PLATE_Z                    0.06672    0.35839   0.186 0.852306
INDUCED_VERTICAL_BREAK    -0.07327    0.02989  -2.452 0.014230 *
HORIZONTAL_BREAK          -0.24674    0.01460 -16.896  < 2e-16 ***
VERTICAL_APPROACH_ANGLE    0.48057    0.25223   1.905 0.056760 .
HORIZONTAL_APPROACH_ANGLE  0.68024    0.08090   8.408  < 2e-16 ***
OPS                       -9.65788    1.63132  -5.920 3.26e-09 ***
Handedness                 8.09336    0.26816  30.181  < 2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1


R-sq.(adj) =  0.098   Deviance explained = 9.83%
GCV = 418.35  Scale est. = 418.18    n = 24510
```

```
gam_Dir_Upd <- bam(DIRECTION ~ RELEASE_SPEED + PLATE_X + INDUCED_VERTICAL_BREAK +
                 HORIZONTAL_BREAK + VERTICAL_APPROACH_ANGLE + HORIZONTAL_APPROACH_ANGLE + OPS + Handedness,
               data = trainDF, family = gaussian, method = "GCV.Cp")


gamEV <- gam_EV_Upd$coefficients
gamAng <- gam_Ang_Upd$coefficients
gamDir <- gam_Dir_Upd$coefficients

trainDF <- trainDF %>% mutate(exitVelo_GAM = round(gamEV[1] + gamEV[2]*RELEASE_SPEED + gamEV[3]*INDUCED_VERTIC
                                                     gamEV[4]*HORIZONTAL_BREAK + gamEV[5]*HORIZONTAL_APPROACH_
                                                     gamEV[6]*OPS + gamEV[7]*Handedness, 3))

trainDF <- trainDF %>% mutate(angle_GAM = round(gamAng[1] + gamAng[2]*RELEASE_SPEED + gamAng[3]*PLATE_X +
                                                     gamAng[4]*PLATE_Z + gamAng[5]*INDUCED_VERTICAL_BREAK +
                                                     gamAng[6]*HORIZONTAL_BREAK + gamAng[7]*VERTICAL_APPROACH_
                                                     gamAng[8]*HORIZONTAL_APPROACH_ANGLE +
                                                     gamAng[9]*OPS + gamAng[10]*Handedness, 3))

trainDF <- trainDF %>% mutate(direction_GAM = round(gamDir[1] + gamDir[2]*RELEASE_SPEED + gamDir[3]*PLATE_X +
                                                     gamDir[4]*INDUCED_VERTICAL_BREAK +
                                                     gamDir[5]*HORIZONTAL_BREAK + gamDir[6]*VERTICAL_APPROACH_
                                                     gamDir[7]*HORIZONTAL_APPROACH_ANGLE +
                                                     gamDir[8]*OPS + gamDir[9]*Handedness, 3))

###smaller gam

gam_Small <- bam(EXIT_SPEED ~ s(PLATE_X, PLATE_Z),
            data = trainDF, family = gaussian, method = "GCV.Cp")

xs <- matrix(data=seq(from=-2, to=2, length=50), nrow=50, ncol=50)
ys <- t(matrix(data=seq(from=0,to=5, length=50), nrow=50, ncol=50))

gamSmallFit <- data.frame(PLATE_X = as.vector(xs), PLATE_Z = as.vector(ys))
exitVeloPred <- predict(gam_Small, gamSmallFit, types = "response")
exitVeloPred <- matrix(exitVeloPred, nrow = 50, ncol = 50)
density(exitVeloPred)
```

```
Call:
    density.default(x = exitVeloPred)
```

```
Data: exitVeloPred (2500 obs.); Bandwidth 'bw' = 1.451

       x               y
 Min.   :56.32   Min.   :2.710e-06
 1st Qu.:66.96   1st Qu.:5.796e-03
 Median :77.59   Median :2.556e-02
 Mean   :77.59   Mean   :2.349e-02
 3rd Qu.:88.22   3rd Qu.:3.826e-02
 Max.   :98.85   Max.   :4.460e-02
```

```
#width of HP is 23in #according to baseball prospectus
#height is 25.79
summary(trainDF$EXIT_SPEED)
```

```
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
  51.29   81.23   91.49   89.32   98.98  118.64
```

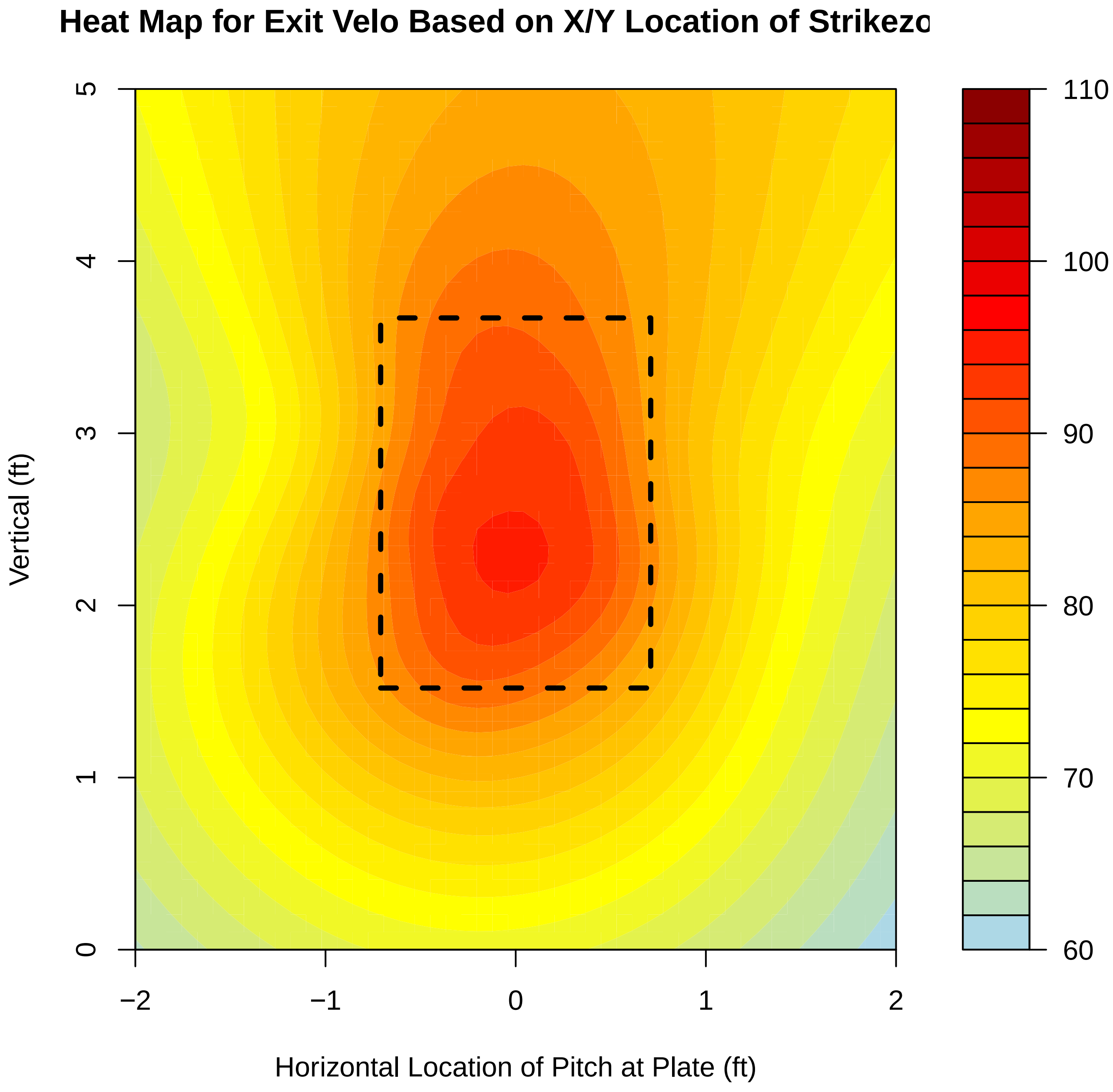
```
summary(trainDF$PLATE_X) #-1.5 to 1.5
```

```
     Min.   1st Qu.    Median      Mean   3rd Qu.      Max.
-1.526430 -0.379685  0.004996 -0.001254  0.372303  1.518160
```

```
summary(trainDF$PLATE_Z) #0.8 to 3.9
```

```
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
 0.8597  2.0195  2.3900  2.3965  2.7676  3.9181
```

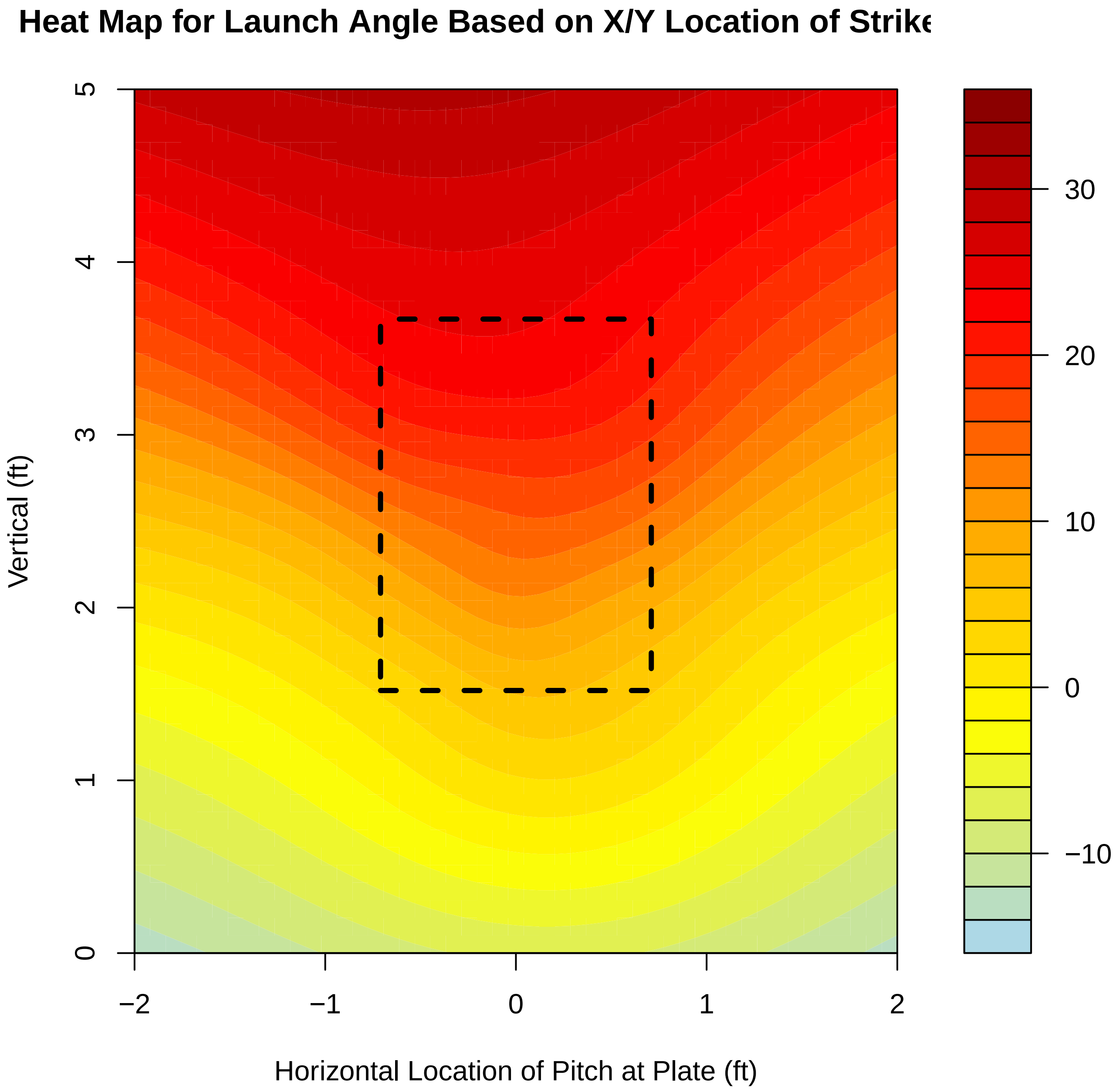
```
filled.contour(x=seq(from=-2, to=2, length=50), y=seq(from=0, to=5, length=50), z = exitVeloPred, zlim=c(60,11
               color.palette = colorRampPalette(c("lightblue","yellow","orange", "red", "darkred")),
               plot.axes = { rect(-0.71, 1.52, 0.71, 3.67, border="black", lty="dashed", lwd=3)
                 axis(1, at=c(-2,-1,0,1,2), pos=0, labels=c(-2,-1,0,1,2), las=0, col="black")
                 axis(2, at=c(0,1,2,3,4,5), pos=-2, labels=c(0,1,2,3,4,5), las=0, col="black")
                 }, main = "Heat Map for Exit Velo Based on X/Y Location of Strikezone", ylab = "Vertical (ft)
```



```
gam_Small2 <- bam(ANGLE ~ s(PLATE_X, PLATE_Z),
                 data = trainDF, family = gaussian, method = "GCV.Cp")
gamSmallFit2 <- data.frame(PLATE_X = as.vector(xs), PLATE_Z = as.vector(ys))
anglePred <- predict(gam_Small2, gamSmallFit2, types = "response")
anglePred <- matrix(anglePred, nrow = 50, ncol = 50)
summary(trainDF$ANGLE)
```

```
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
-58.917  -4.377  13.619  13.177  29.796  82.393
```

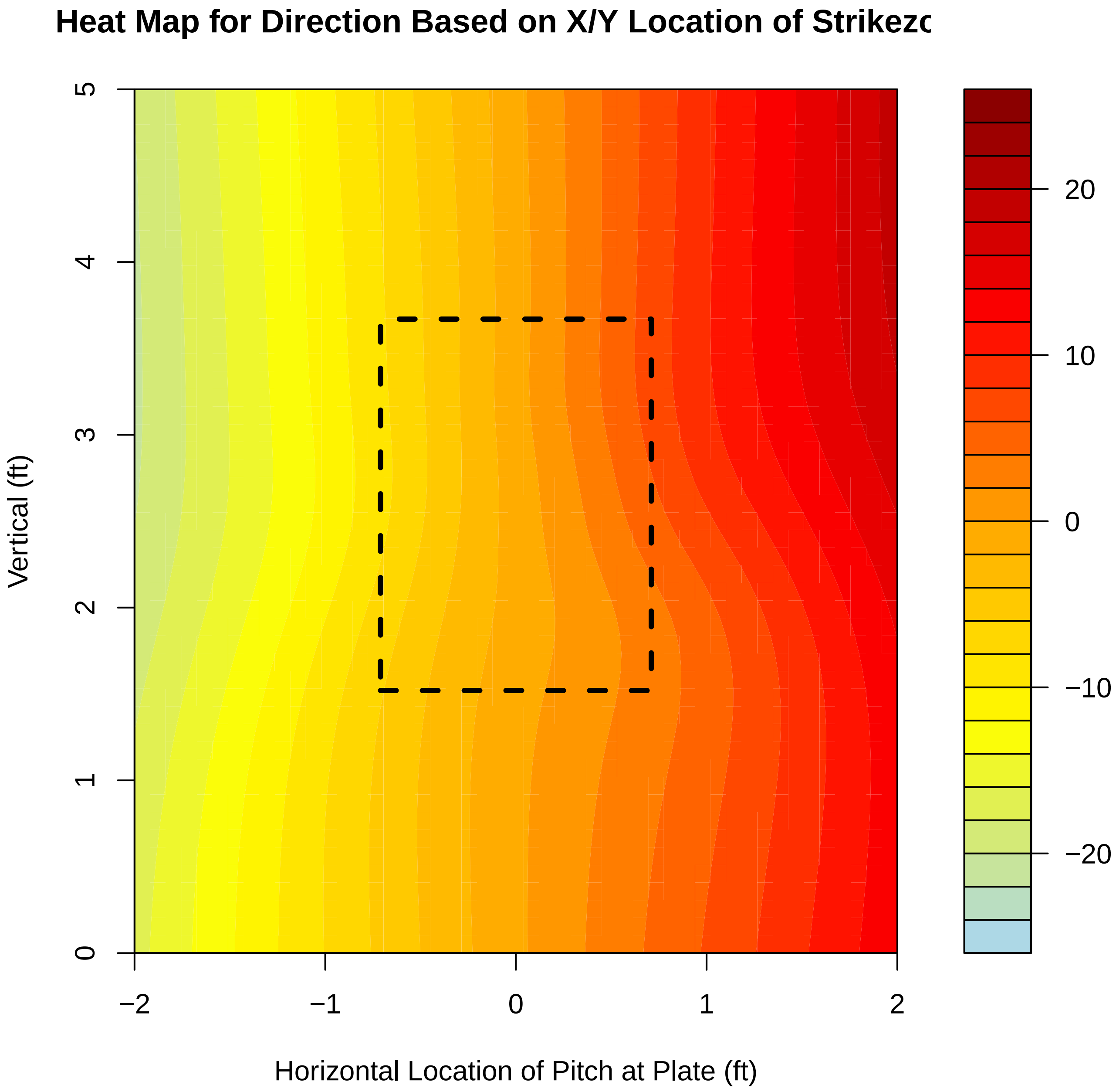
```
filled.contour(x=seq(from=-2, to=2, length=50), y=seq(from=0, to=5, length=50), z = anglePred, zlim=c(-15,35),
               color.palette = colorRampPalette(c("lightblue","yellow","orange", "red", "darkred")),
               plot.axes = { rect(-0.71, 1.52, 0.71, 3.67, border="black", lty="dashed", lwd=3)
                 axis(1, at=c(-2,-1,0,1,2), pos=0, labels=c(-2,-1,0,1,2), las=0, col="black")
                 axis(2, at=c(0,1,2,3,4,5), pos=-2, labels=c(0,1,2,3,4,5), las=0, col="black")
               }, main = "Heat Map for Launch Angle Based on X/Y Location of Strikezone", ylab = "Vertical (ft
```



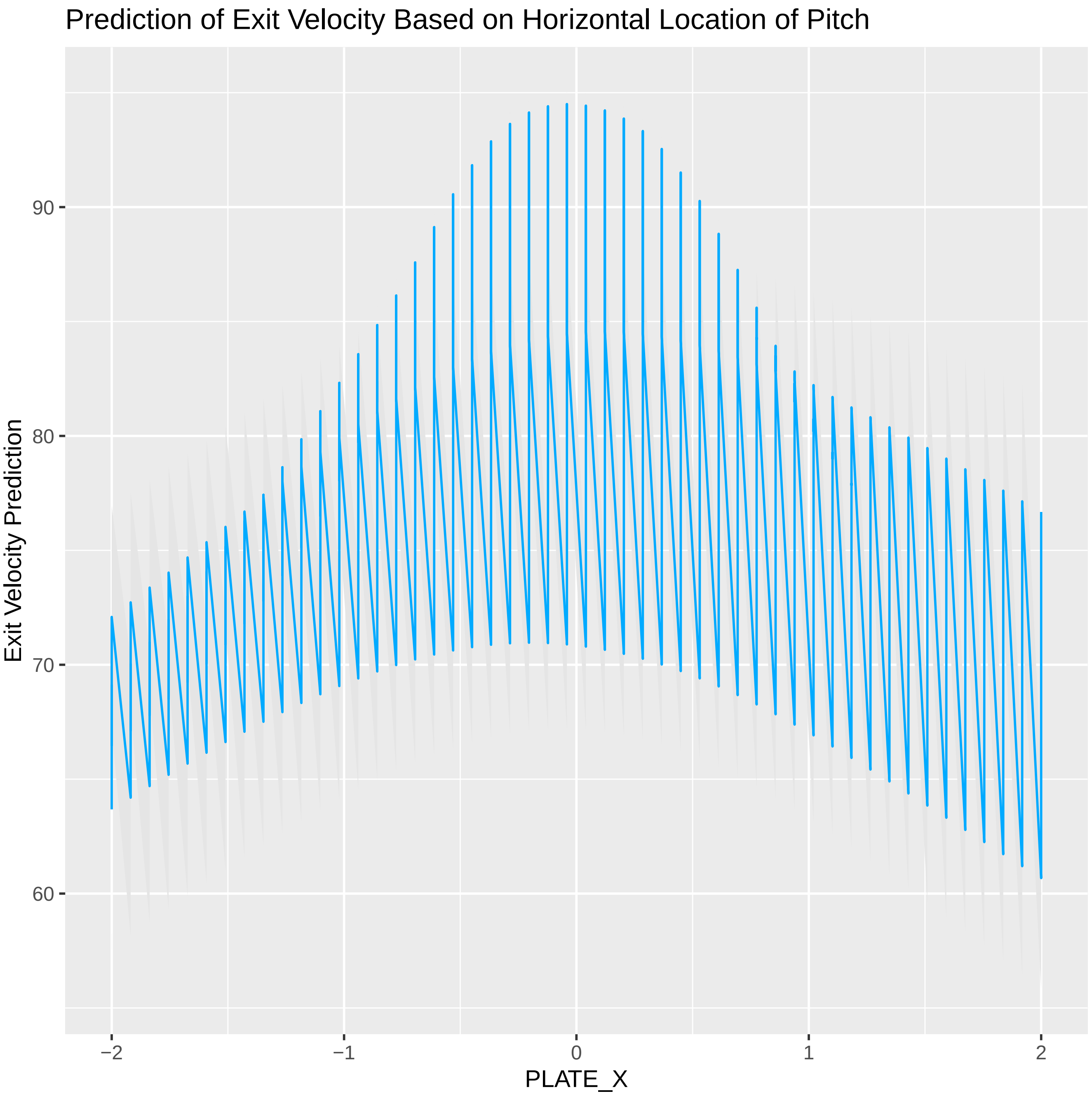
```
gam_Small3 <- bam(DIRECTION ~ s(PLATE_X, PLATE_Z),
                  data = trainDF, family = gaussian, method = "GCV.Cp")
gamSmallFit3 <- data.frame(PLATE_X = as.vector(xs), PLATE_Z = as.vector(ys))
directionPred <- predict(gam_Small3, gamSmallFit3, types = "response")
directionPred <- matrix(directionPred, nrow = 50, ncol = 50)
summary(trainDF$DIRECTION)
```

```
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
-68.576 -17.733  -1.480  -1.374  14.795  65.317
```

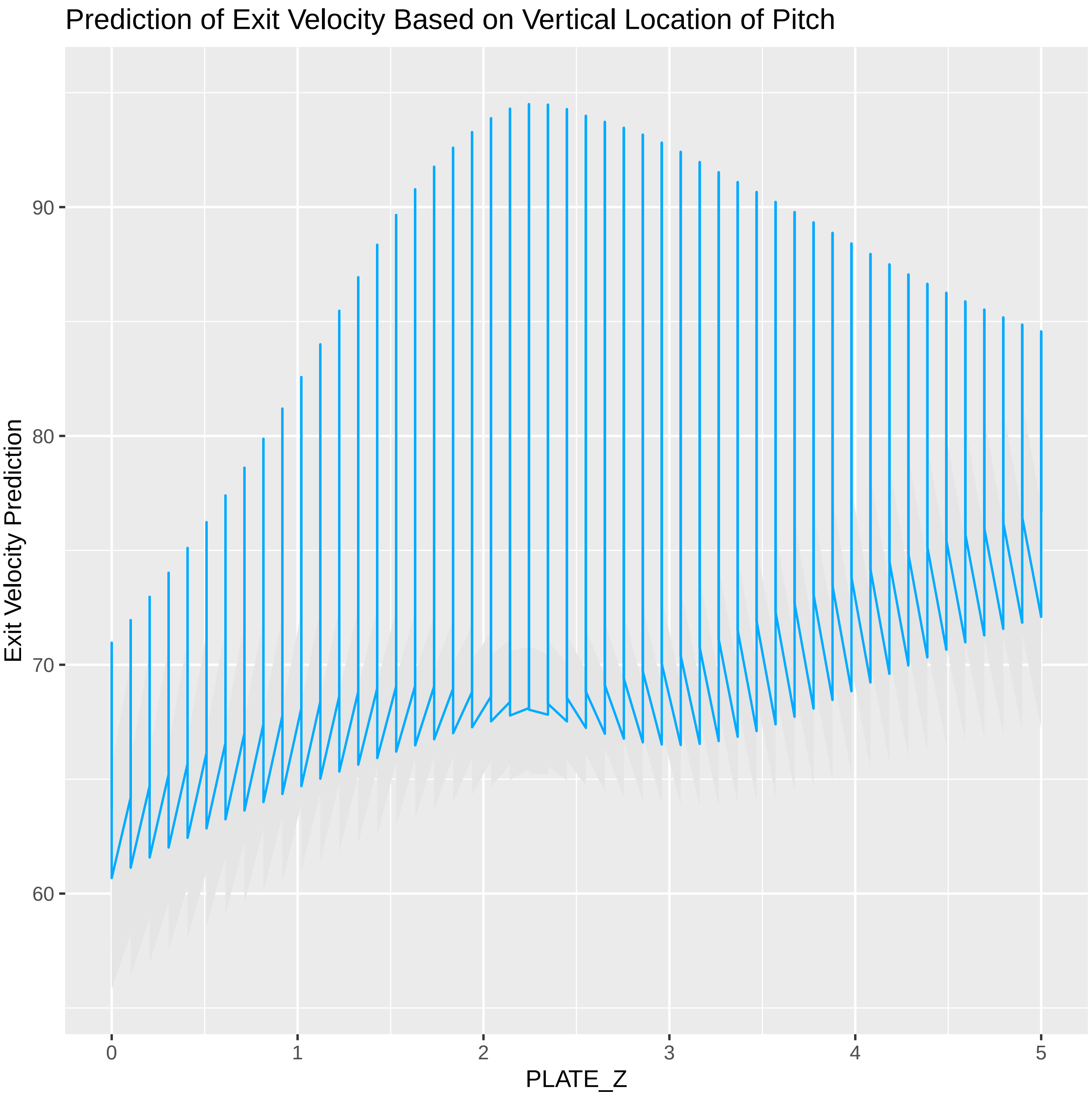
```
#not taking into account handedness (l/r are combined here)
filled.contour(x=seq(from=-2, to=2, length=50), y=seq(from=0, to=5, length=50), z = directionPred, zlim=c(-25,
               color.palette = colorRampPalette(c("lightblue","yellow","orange", "red", "darkred")),
               plot.axes = { rect(-0.71, 1.52, 0.71, 3.67, border="black", lty="dashed", lwd=3)
                 axis(1, at=c(-2,-1,0,1,2), pos=0, labels=c(-2,-1,0,1,2), las=0, col="black")
                 axis(2, at=c(0,1,2,3,4,5), pos=-2, labels=c(0,1,2,3,4,5), las=0, col="black")
               }, main = "Heat Map for Direction Based on X/Y Location of Strikezone", ylab = "Vertical (ft)",
```



```
exitVeloPredConf <- predict(gam_Small, gamSmallFit, types = "response", se = TRUE)
predVals <- data.frame(gamSmallFit, exitVeloPredConf) %>%
  mutate(lower = exitVeloPredConf$fit - 1.96*exitVeloPredConf$se.fit,
         upper = exitVeloPredConf$fit + 1.96*exitVeloPredConf$se.fit)

ggplot(aes(x=PLATE_X,y=exitVeloPredConf$fit), data=predVals) +
  geom_ribbon(aes(ymin = lower, ymax=upper), fill='gray90') +
  geom_line(color='#00aaff') + ylab("Exit Velocity Prediction") +
  ggtitle("Prediction of Exit Velocity Based on Horizontal Location of Pitch")
```

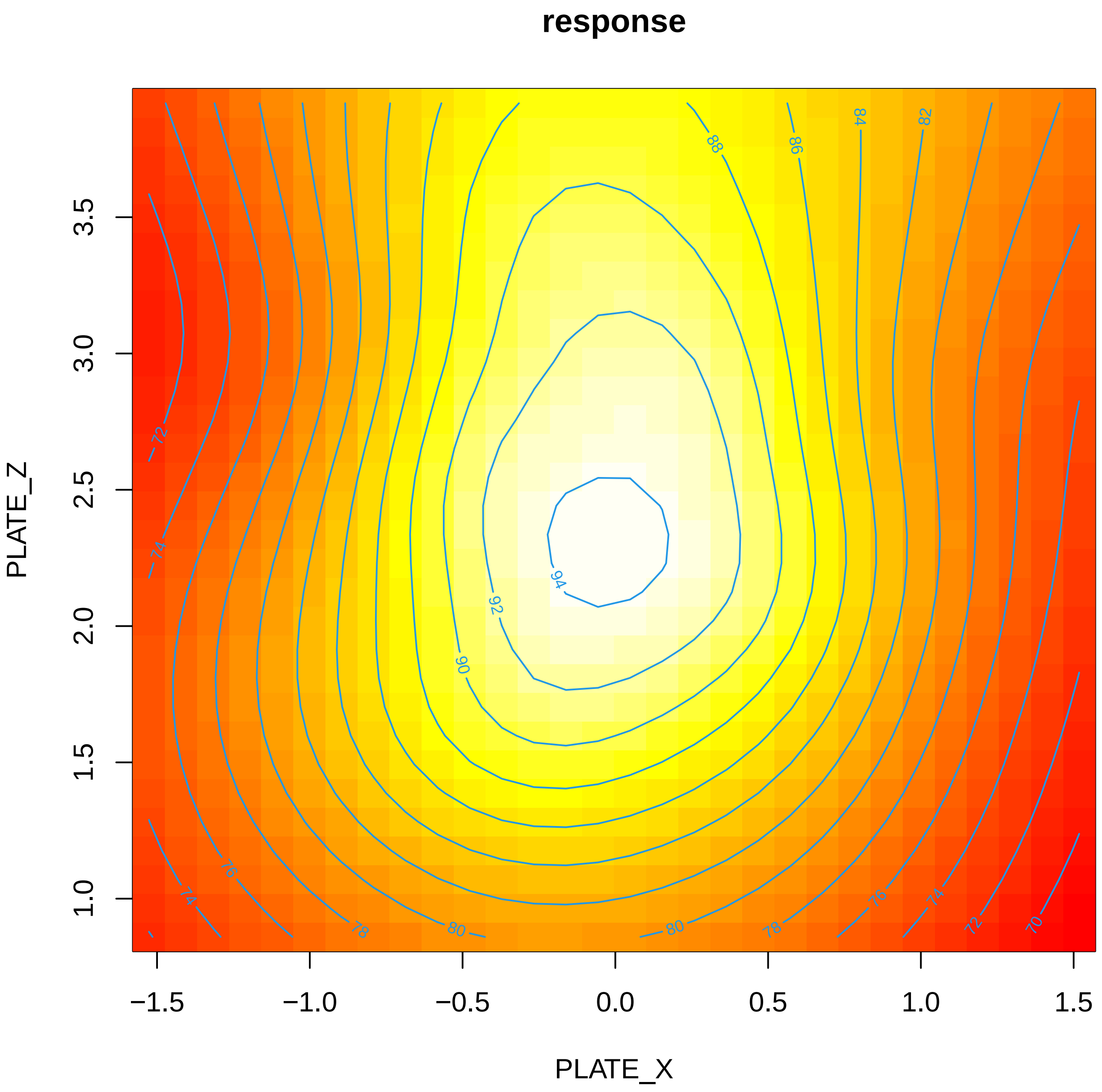


```
ggplot(aes(x=PLATE_Z,y=exitVeloPredConf$fit), data=predVals) +
  geom_ribbon(aes(ymin = lower, ymax=upper), fill='gray90') +
  geom_line(color='#00aaff') + ylab("Exit Velocity Prediction") +
  ggtitle("Prediction of Exit Velocity Based on Vertical Location of Pitch")
```

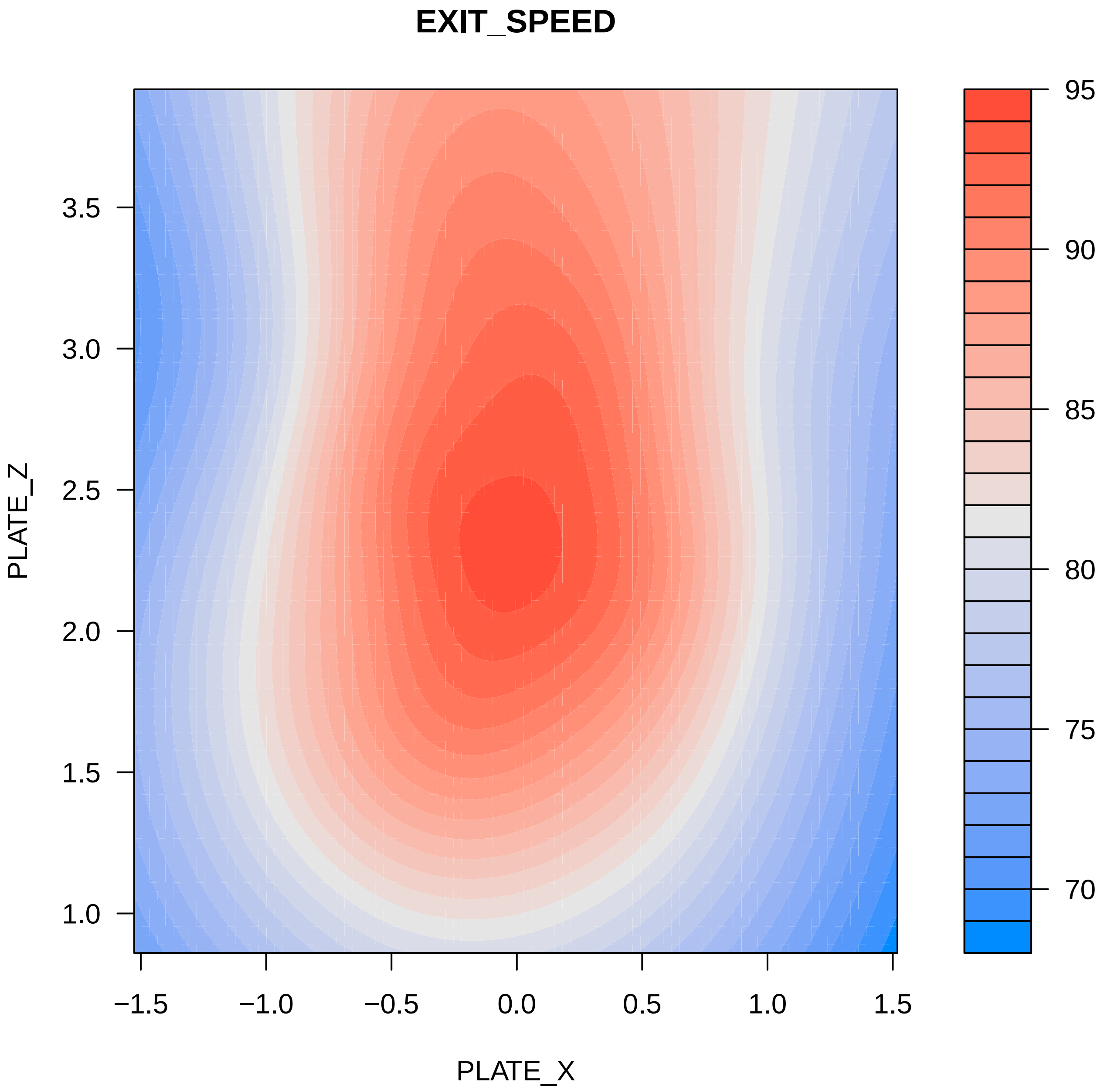


```
# ggsave("name.png")
```

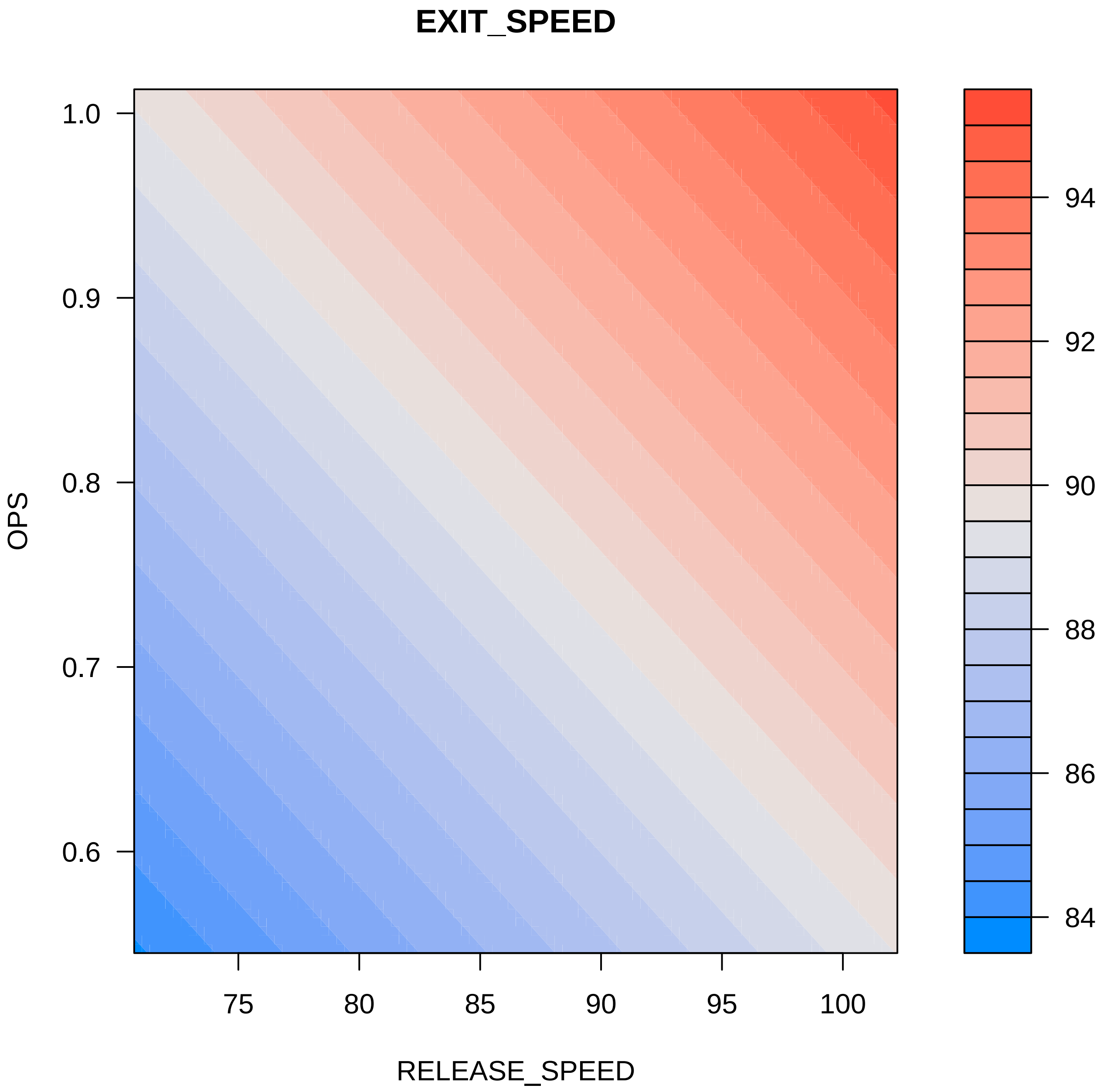
```
vis.gam(gam_Small, type='response', plot.type='contour')
```



```
visreg2d(gam_Small, xvar='PLATE_X', yvar='PLATE_Z', scale='response')
```



```
visreg2d(gam_EV_Upd, xvar='RELEASE_SPEED', yvar='OPS', scale='response')
```



```
anova(gam_EV_Upd, gam_Small, test="Chisq")
```

```
Analysis of Deviance Table

Model 1: EXIT_SPEED ~ RELEASE_SPEED + INDUCED_VERTICAL_BREAK + HORIZONTAL_BREAK +
    HORIZONTAL_APPROACH_ANGLE + OPS + Handedness
Model 2: EXIT_SPEED ~ s(PLATE_X, PLATE_Z)
  Resid. Df Resid. Dev     Df Deviance  Pr(>Chi)
1     24503    3779820
2     24482    3334731 20.664   445089 < 2.2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
anova(gam_EV_Upd)
```

```
Family: gaussian
Link function: identity

Formula:
```

```
EXIT_SPEED ~ RELEASE_SPEED + INDUCED_VERTICAL_BREAK + HORIZONTAL_BREAK +
    HORIZONTAL_APPROACH_ANGLE + OPS + Handedness

Parametric Terms:
                          df       F  p-value
RELEASE_SPEED              1  74.264  < 2e-16
INDUCED_VERTICAL_BREAK     1   3.892   0.0485
HORIZONTAL_BREAK           1   6.122   0.0134
HORIZONTAL_APPROACH_ANGLE  1   2.810   0.0937
OPS                        1 152.669  < 2e-16
Handedness                 1  17.063 3.63e-05

anova(gam_Ang_Upd)

Family: gaussian
Link function: identity

Formula:
ANGLE ~ RELEASE_SPEED + PLATE_X + PLATE_Z + INDUCED_VERTICAL_BREAK +
    HORIZONTAL_BREAK + VERTICAL_APPROACH_ANGLE + HORIZONTAL_APPROACH_ANGLE +
    OPS + Handedness

Parametric Terms:
                          df       F  p-value
RELEASE_SPEED              1 522.915  < 2e-16
PLATE_X                    1  13.701 0.000215
PLATE_Z                    1 378.906  < 2e-16
INDUCED_VERTICAL_BREAK     1 507.219  < 2e-16
HORIZONTAL_BREAK           1  13.454 0.000245
VERTICAL_APPROACH_ANGLE    1   3.563 0.059084
HORIZONTAL_APPROACH_ANGLE  1  64.218 1.16e-15
OPS                        1  16.473 4.95e-05
Handedness                 1  12.370 0.000437

anova(gam_Dir_Upd)

Family: gaussian
Link function: identity

Formula:
DIRECTION ~ RELEASE_SPEED + PLATE_X + INDUCED_VERTICAL_BREAK +
    HORIZONTAL_BREAK + VERTICAL_APPROACH_ANGLE + HORIZONTAL_APPROACH_ANGLE +
    OPS + Handedness

Parametric Terms:
                          df        F  p-value
RELEASE_SPEED              1   13.982 0.000185
PLATE_X                    1 1216.430  < 2e-16
INDUCED_VERTICAL_BREAK     1    7.122 0.007618
HORIZONTAL_BREAK           1  286.490  < 2e-16
VERTICAL_APPROACH_ANGLE    1    8.440 0.003674
HORIZONTAL_APPROACH_ANGLE  1   70.704  < 2e-16
OPS                        1   35.056 3.25e-09
Handedness                 1  915.549  < 2e-16

######################GLM model
############exit velo
exitVeloCalc <- glm(EXIT_SPEED ~ RELEASE_SPEED + PLATE_X + PLATE_Z + INDUCED_VERTICAL_BREAK + HORIZONTAL_BREAK
                      VERTICAL_APPROACH_ANGLE + HORIZONTAL_APPROACH_ANGLE + OPS + Handedness,
                  data = trainDF,
                  family = gaussian)
summary(exitVeloCalc)
```

```

Call:
glm(formula = EXIT_SPEED ~ RELEASE_SPEED + PLATE_X + PLATE_Z +
    INDUCED_VERTICAL_BREAK + HORIZONTAL_BREAK + VERTICAL_APPROACH_ANGLE +
    HORIZONTAL_APPROACH_ANGLE + OPS + Handedness, family = gaussian,
    data = trainDF)

Deviance Residuals:
    Min       1Q   Median       3Q      Max
-40.874   -7.901    2.099    9.573   31.016

Coefficients:
                          Estimate Std. Error t value Pr(>|t|)
(Intercept)               62.49285    3.30876  18.887  < 2e-16 ***
RELEASE_SPEED              0.18434    0.02492   7.398 1.42e-13 ***
PLATE_X                    0.07433    0.17082   0.435   0.6635
PLATE_Z                    0.06586    0.21768   0.303   0.7622
INDUCED_VERTICAL_BREAK     0.03296    0.01815   1.816   0.0694 .
HORIZONTAL_BREAK          -0.02235    0.00887  -2.520   0.0118 *
VERTICAL_APPROACH_ANGLE   -0.06991    0.15320  -0.456   0.6482
HORIZONTAL_APPROACH_ANGLE -0.08299    0.04914  -1.689   0.0912 .
OPS                       12.22985    0.99085  12.343  < 2e-16 ***
Handedness                 0.66970    0.16287   4.112 3.94e-05 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for gaussian family taken to be 154.2758)

    Null deviance: 3843946  on 24509  degrees of freedom
Residual deviance: 3779758  on 24500  degrees of freedom
AIC: 193068

Number of Fisher Scoring iterations: 2
```

```
exitVeloCalc$coefficients #coefficients used to determine exit velo
```

```
              (Intercept)             RELEASE_SPEED                   PLATE_X
              62.49285293                0.18433823                0.07433175
                  PLATE_Z    INDUCED_VERTICAL_BREAK          HORIZONTAL_BREAK
               0.06586319                0.03296162               -0.02234830
  VERTICAL_APPROACH_ANGLE HORIZONTAL_APPROACH_ANGLE                       OPS
              -0.06991142               -0.08298921               12.22984853
               Handedness
               0.66969731
```

```
anova(exitVeloCalc, test = "Chisq")
```

```
Analysis of Deviance Table

Model: gaussian, link: identity

Response: EXIT_SPEED

Terms added sequentially (first to last)


                          Df Deviance Resid. Df Resid. Dev  Pr(>Chi)
```

```
NULL                                     24509    3843946
RELEASE_SPEED              1    35498     24508    3808449 < 2.2e-16 ***
PLATE_X                    1      106     24507    3808343  0.407391
PLATE_Z                    1        0     24506    3808342  0.964155
INDUCED_VERTICAL_BREAK     1     1266     24505    3807077  0.004179 **
HORIZONTAL_BREAK           1      792     24504    3806285  0.023460 *
VERTICAL_APPROACH_ANGLE    1       29     24503    3806256  0.665747
HORIZONTAL_APPROACH_ANGLE  1     1088     24502    3805167  0.007905 **
OPS                        1    22801     24501    3782366 < 2.2e-16 ***
Handedness                 1     2608     24500    3779758 3.927e-05 ***
---
Signif. codes:  0 ’***’ 0.001 ’**’ 0.01 ’*’ 0.05 ’.’ 0.1 ’ ’ 1
```

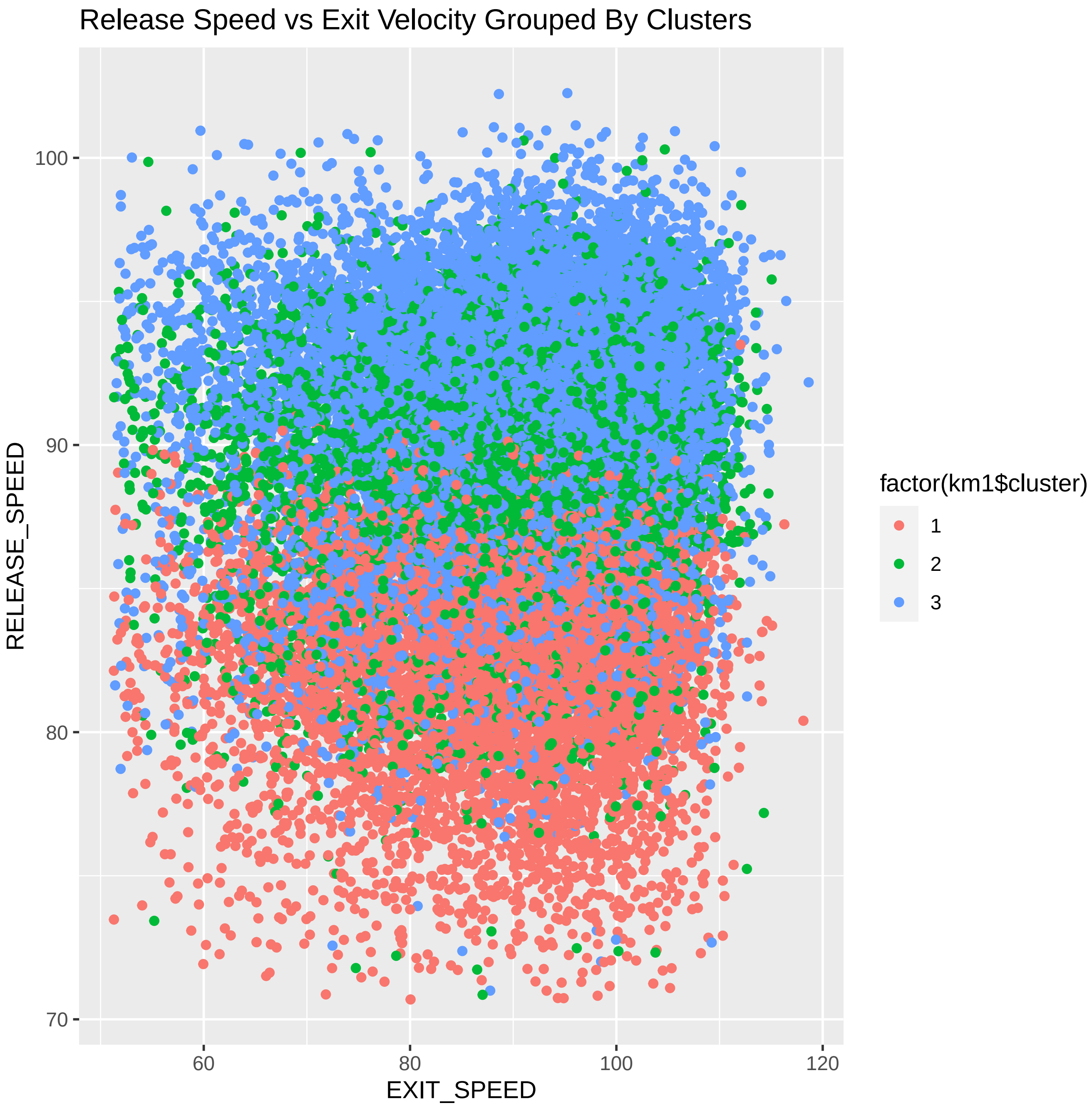
```
############angle
angleCalc <- glm(ANGLE ~ RELEASE_SPEED + PLATE_X + PLATE_Z + INDUCED_VERTICAL_BREAK + HORIZONTAL_BREAK +
                      VERTICAL_APPROACH_ANGLE + HORIZONTAL_APPROACH_ANGLE + OPS + Handedness,
                    data = trainDF,
                    family = gaussian)
anova(angleCalc, test = "Chisq")
```

```
Analysis of Deviance Table

Model: gaussian, link: identity

Response: ANGLE

Terms added sequentially (first to last)

                          Df Deviance Resid. Df Resid. Dev  Pr(>Chi)
NULL                                     24509   15217969
RELEASE_SPEED              1    13523     24508   15204446 1.121e-06 ***
PLATE_X                    1      368     24507   15204078 0.4220621
PLATE_Z                    1   686790     24506   14517288 < 2.2e-16 ***
INDUCED_VERTICAL_BREAK     1   484625     24505   14032663 < 2.2e-16 ***
HORIZONTAL_BREAK           1     7192     24504   14025471 0.0003839 ***
VERTICAL_APPROACH_ANGLE    1     3371     24503   14022100 0.0150540 *
HORIZONTAL_APPROACH_ANGLE  1    31636     24502   13990464 9.525e-14 ***
OPS                        1     8640     24501   13981824 9.941e-05 ***
Handedness                 1     7056     24500   13974768 0.0004363 ***
---
Signif. codes:  0 ’***’ 0.001 ’**’ 0.01 ’*’ 0.05 ’.’ 0.1 ’ ’ 1
```

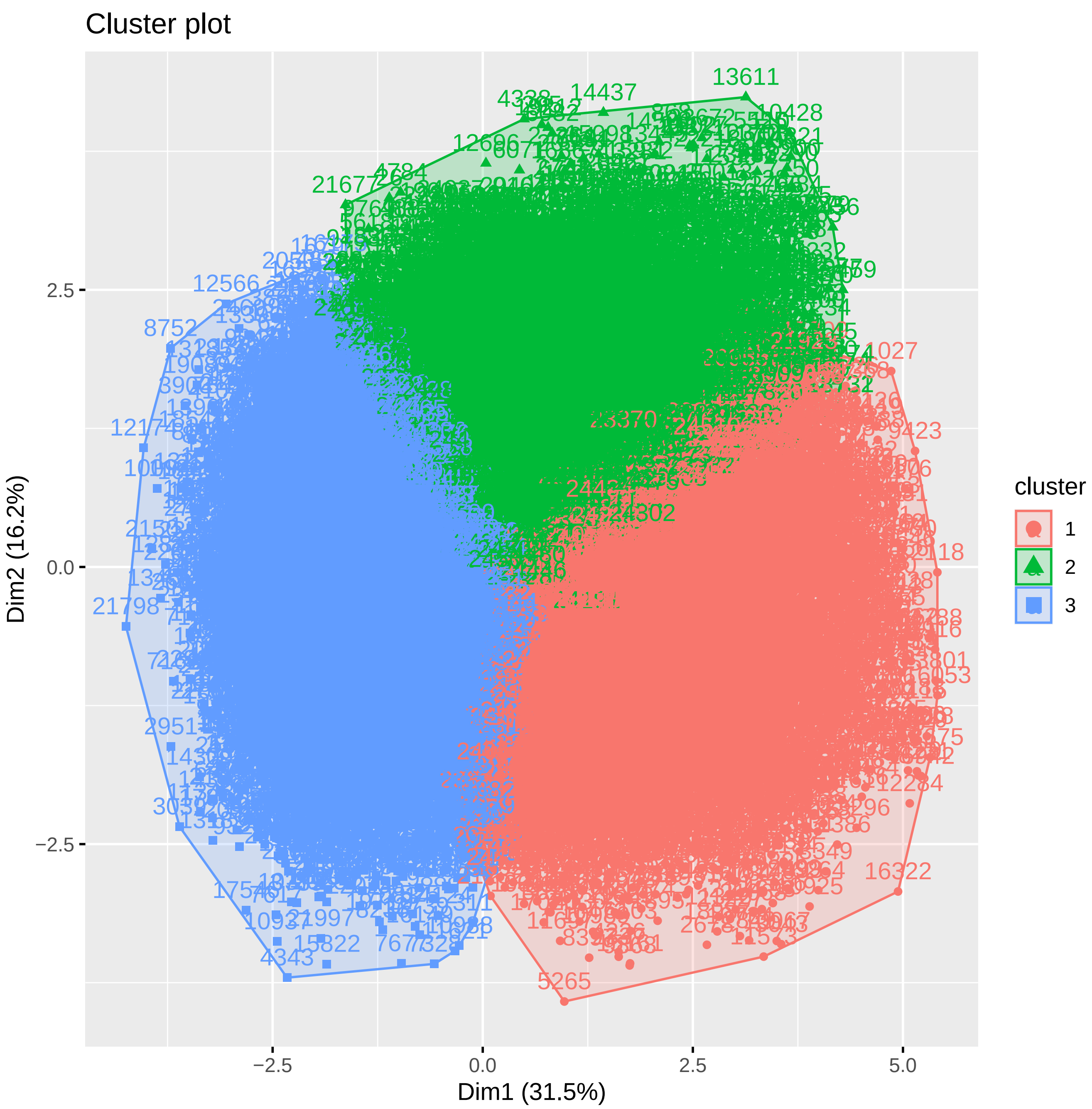
```
############direction
directionCalc <- glm(DIRECTION ~ RELEASE_SPEED + PLATE_X + PLATE_Z + INDUCED_VERTICAL_BREAK + HORIZONTAL_BREAK
                      VERTICAL_APPROACH_ANGLE + HORIZONTAL_APPROACH_ANGLE + OPS + Handedness,
                    data = trainDF,
                    family = gaussian)
anova(directionCalc, test = "Chisq")
```

```
Analysis of Deviance Table

Model: gaussian, link: identity

Response: DIRECTION

Terms added sequentially (first to last)

                          Df Deviance Resid. Df Resid. Dev  Pr(>Chi)
NULL                                     24509   11362518
```

```
RELEASE_SPEED              1    37027     24508   11325490 < 2.2e-16 ***
PLATE_X                    1   559080     24507   10766410 < 2.2e-16 ***
PLATE_Z                    1      407     24506   10766003  0.323712
INDUCED_VERTICAL_BREAK     1      378     24505   10765625  0.341485
HORIZONTAL_BREAK           1   108229     24504   10657396 < 2.2e-16 ***
VERTICAL_APPROACH_ANGLE    1     3662     24503   10653734  0.003085 **
HORIZONTAL_APPROACH_ANGLE  1     4473     24502   10649261  0.001073 **
OPS                        1    22892     24501   10626369 1.375e-13 ***
Handedness                 1   380929     24500   10245440 < 2.2e-16 ***
---
Signif. codes:  0 ’***’ 0.001 ’**’ 0.01 ’*’ 0.05 ’.’ 0.1 ’ ’ 1

evc <- exitVeloCalc$coefficients
ac <- angleCalc$coefficients
dc <- directionCalc$coefficients


trainDF <- trainDF %>%
  mutate(exitVelo_GLM = round(evc[1] + evc[2]*RELEASE_SPEED + evc[3]*PLATE_X + evc[4]*PLATE_Z +
                                evc[5]*INDUCED_VERTICAL_BREAK + evc[6]*HORIZONTAL_BREAK +
                                evc[7]*VERTICAL_APPROACH_ANGLE +
                                evc[8]*HORIZONTAL_APPROACH_ANGLE + evc[9]*OPS + evc[10]*Handedness, 3))


trainDF <- trainDF %>%
  mutate(angle_GLM = round(ac[1] + ac[2]*RELEASE_SPEED + ac[3]*PLATE_X + ac[4]*PLATE_Z +
                             ac[5]*INDUCED_VERTICAL_BREAK + ac[6]*HORIZONTAL_BREAK +
                             ac[7]*VERTICAL_APPROACH_ANGLE +
                             ac[8]*HORIZONTAL_APPROACH_ANGLE + ac[9]*OPS + ac[10]*Handedness, 3))

trainDF <- trainDF %>%
  mutate(direction_GLM = round(dc[1] + dc[2]*RELEASE_SPEED + dc[3]*PLATE_X + dc[4]*PLATE_Z +
                                 dc[5]*INDUCED_VERTICAL_BREAK + dc[6]*HORIZONTAL_BREAK +
                                 dc[7]*VERTICAL_APPROACH_ANGLE +
                                 dc[8]*HORIZONTAL_APPROACH_ANGLE + dc[9]*OPS + dc[10]*Handedness, 3))

###################################################Kmeans

subsetTrain <- trainDF[,c(19, 12:18, 29:30)]
km1 <- kmeans(subsetTrain[,2:10], 3, iter.max = 100)

ggplot(trainDF, aes(x = EXIT_SPEED, y = RELEASE_SPEED, color = factor(km1$cluster))) + geom_point() +
  ggtitle("Release Speed vs Exit Velocity Grouped By Clusters")
```



```
km2 <- kmeans(scale(trainDF[, c(12:18, 29:30)]), 3, nstart = 25, iter.max = 100)
fviz_cluster(km2, data = trainDF[, c(12:18, 29:30)])
```

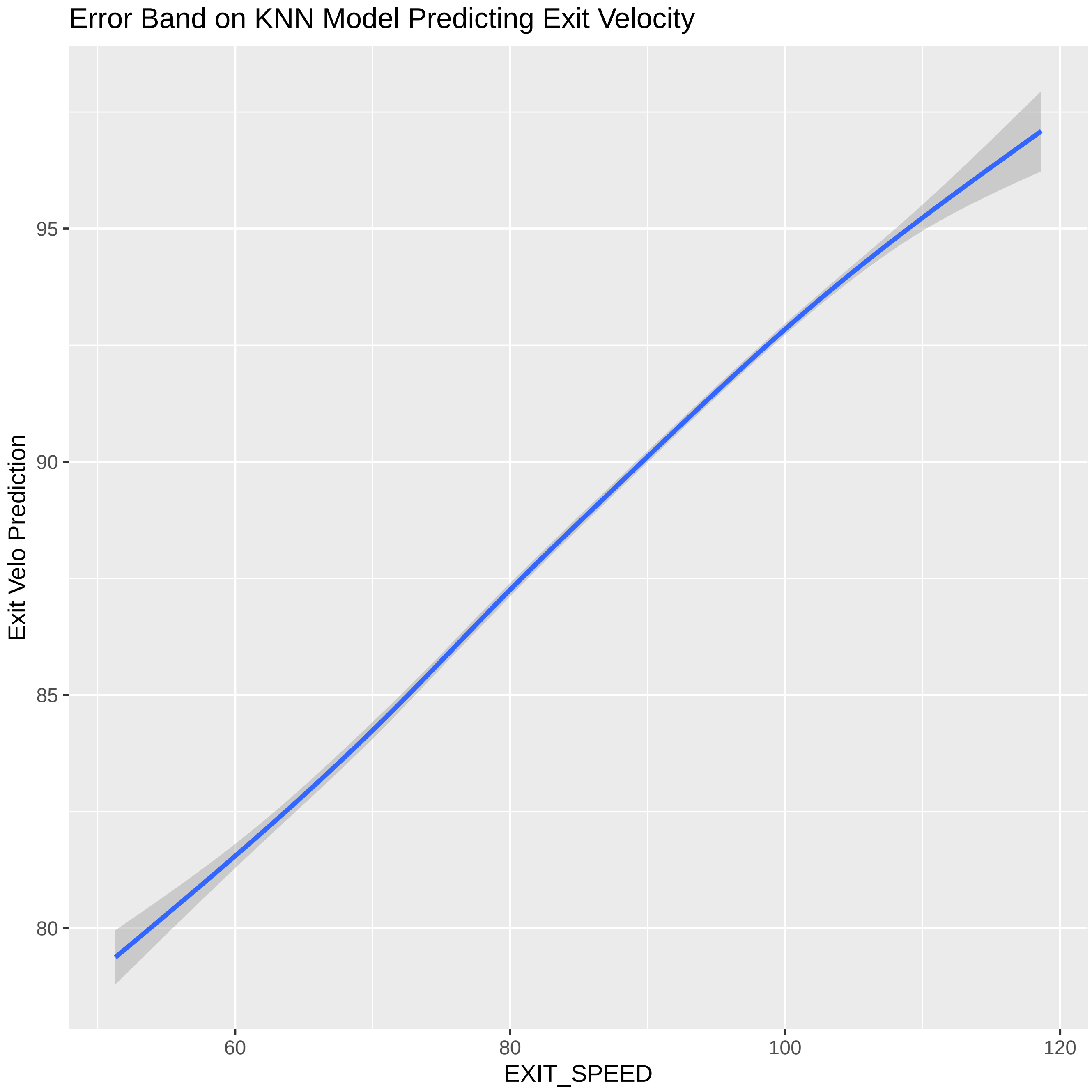


```
# Dimension reduction PCA
pca <- prcomp(trainDF[, c(12:18, 29:30)],  scale = TRUE)
cords <- as.data.frame(get_pca_ind(pca)$coord)
cords$cluster1 <- factor(km2$cluster)
cords$EXIT_SPEED <- trainDF$EXIT_SPEED
head(cords) #see first few rows dimensions and clusters
```

```
       Dim.1        Dim.2      Dim.3      Dim.4      Dim.5      Dim.6
1 -0.2670835 -0.612154122 -1.5278253 -3.0041345 -1.5721867 -0.6846484
2 -1.6181788 -0.685284226 -1.1083727 -1.5976944 -0.0713787  0.5994411
3 -0.7583726  0.615782416  1.7885790 -0.4184670  1.1029973  0.9452969
4  2.1475458  2.563730676 -0.3782569  0.8190211 -0.5348873  0.1488507
5 -1.8329566  0.005665152 -1.9021775  0.1834935  1.6097560 -0.2961044
6  0.4233652  0.720917324  1.3316927 -0.4232247 -0.5920003 -0.2493779
       Dim.7       Dim.8        Dim.9 cluster1 EXIT_SPEED
1  0.3249521  0.01195926  0.181060498        3   83.65304
2  0.3777947 -0.26351196 -0.054952233        3   95.66794
```

```
3  0.9258171  0.37129333 -0.166779325        3   86.94758
4  1.2165254  0.42395082 -0.032647612        2   76.26321
5 -0.2560795  0.26898614  0.009755342        3   87.25558
6  1.1292003 -1.62054318  0.077016925        2   82.83160
```

```
###############KNN
#######knn on exit velo
trainKNN_x_EV <- trainDF[,c(12:18,29:30)]
trainKNN_y_EV <- trainDF[,19]
knnModel_EV <- knnreg(trainKNN_x_EV, trainKNN_y_EV)
testKNN_x_EV <- testDF[,c(12:20)]

knnpred_y_EV <- predict(knnModel_EV, data.frame(testKNN_x_EV))

knnpred_xTconf_EV <- predict(knnModel_EV, data.frame(trainKNN_x_EV), interval = "confidence", level = 0.9)
ggplot(trainDF, aes(EXIT_SPEED, knnpred_xTconf_EV)) + geom_smooth() +
  ggtitle("Error Band on KNN Model Predicting Exit Velocity") + ylab("Exit Velo Prediction")
```



```
mse <- mean((trainKNN_y_EV - knnpred_xTconf_EV)^2)
mae <- MAE(trainKNN_y_EV, knnpred_xTconf_EV)
rmse <- RMSE(trainKNN_y_EV, knnpred_xTconf_EV)
mse
```

```
[1] 109.4011
```

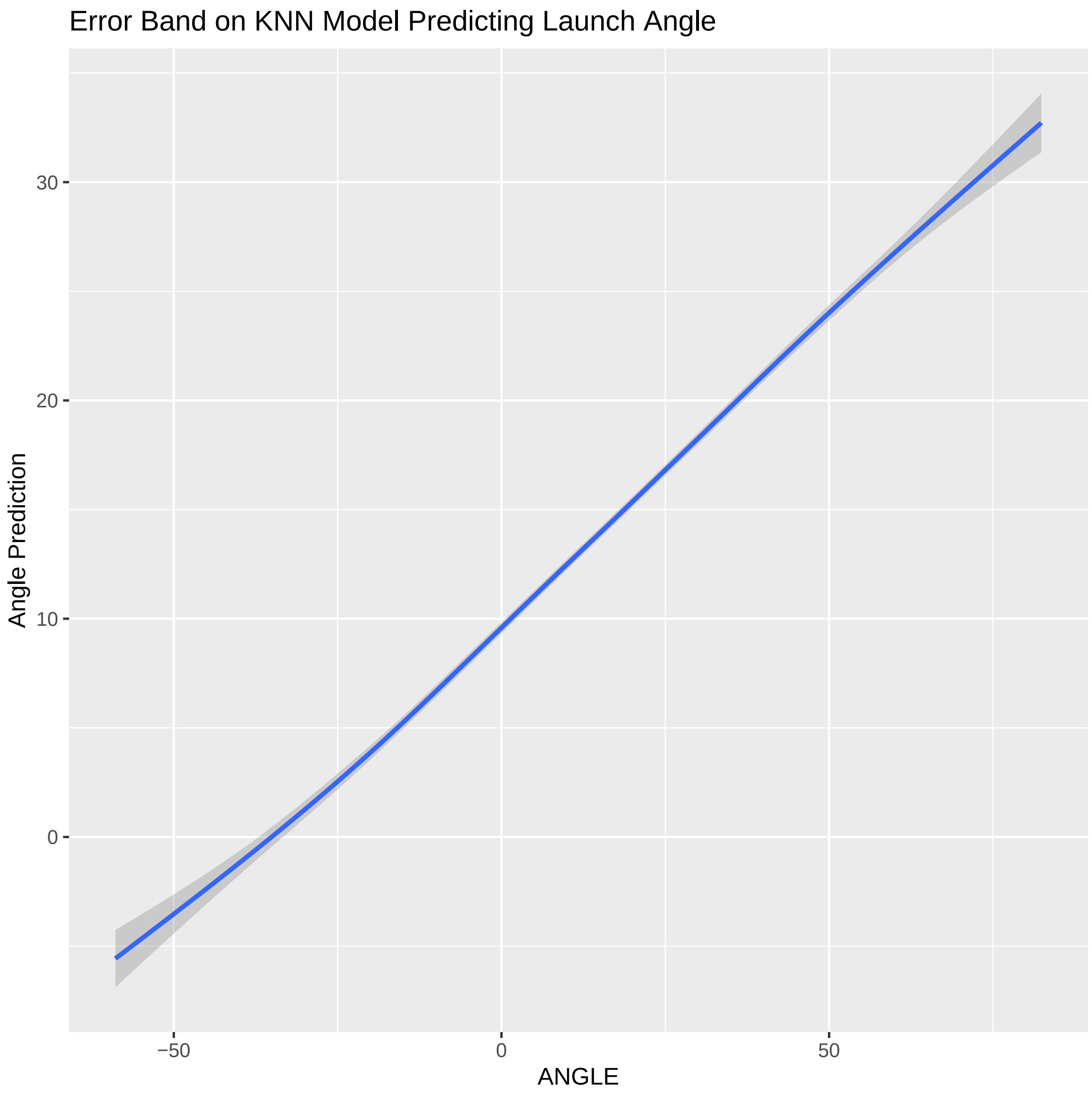
```
mae
```

```
[1] 8.328806
```

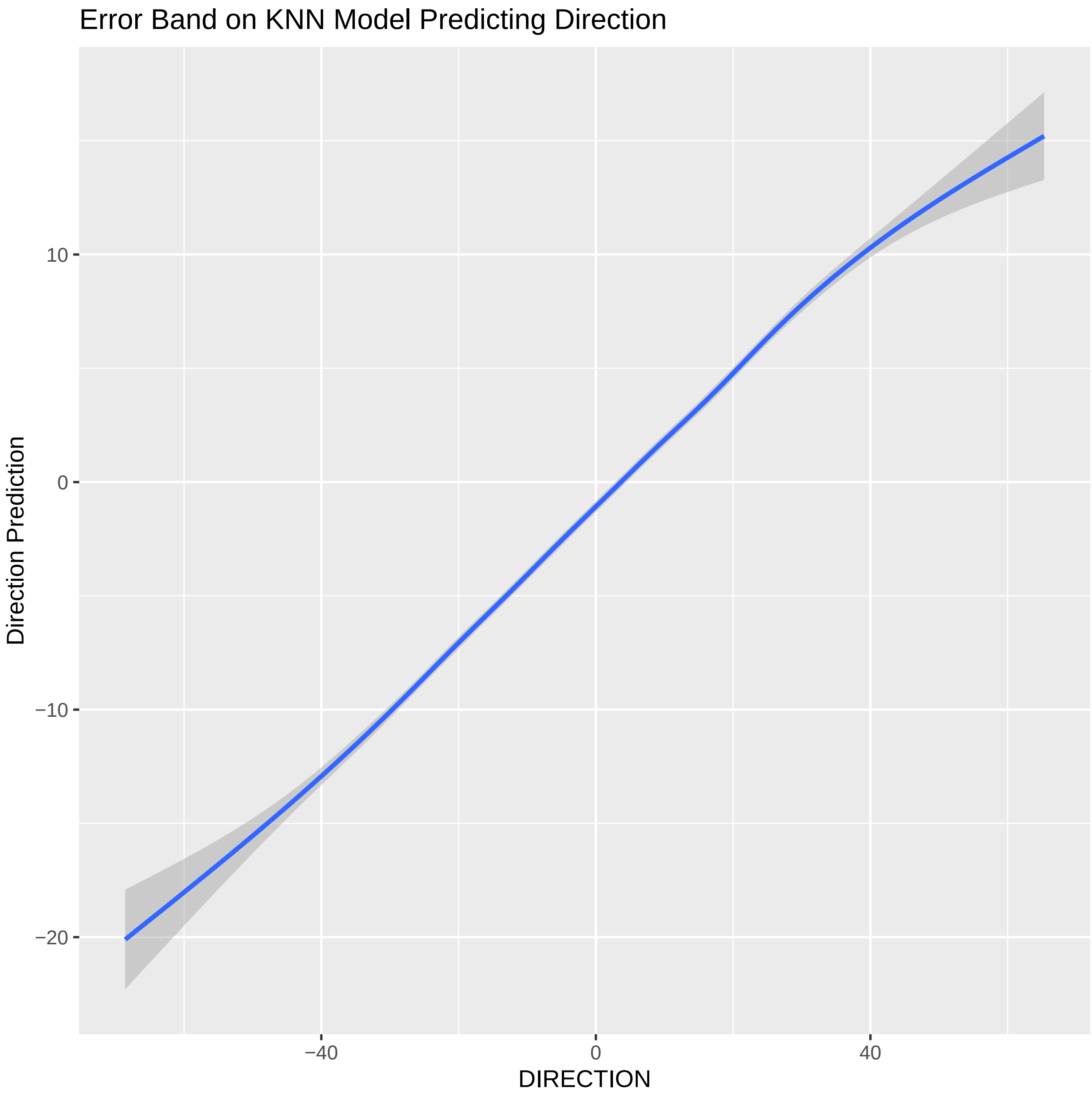
```
rmse
```

```
[1] 10.4595
```

```
#####knn on angle
trainKNN_x_ang <- trainDF[,c(12:18,29:30)]
trainKNN_y_ang <- trainDF[,20]
knnModel_ang <- knnreg(trainKNN_x_ang, trainKNN_y_ang)
testKNN_x_ang <- testDF[,c(12:20)]

knnpred_y_ang <- predict(knnModel_ang, data.frame(testKNN_x_ang))

knnpred_xTconf_ang <- predict(knnModel_ang, data.frame(trainKNN_x_ang), interval = "confidence", level = 0.9)
ggplot(trainDF, aes(ANGLE, knnpred_xTconf_ang)) + geom_smooth() +
  ggtitle("Error Band on KNN Model Predicting Launch Angle") + ylab("Angle Prediction")
```



```
#####knn on direction
trainKNN_x_dir <- trainDF[,c(12:18,29:30)]
trainKNN_y_dir <- trainDF[,21]
knnModel_dir <- knnreg(trainKNN_x_dir, trainKNN_y_dir)
testKNN_x_dir <- testDF[,c(12:20)]

knnpred_y_dir <- predict(knnModel_dir, data.frame(testKNN_x_dir))

knnpred_xTconf_dir <- predict(knnModel_dir, data.frame(trainKNN_x_dir), interval = "confidence", level = 0.9)
ggplot(trainDF, aes(DIRECTION, knnpred_xTconf_dir)) + geom_smooth() +
  ggtitle("Error Band on KNN Model Predicting Direction") + ylab("Direction Prediction")
```



```
trainDF <- trainDF %>% mutate(exitVelo_KNN = round(knnpred_xTconf_EV,3))
trainDF <- trainDF %>% mutate(angle_KNN = round(knnpred_xTconf_ang,3))
trainDF <- trainDF %>% mutate(direction_KNN = round(knnpred_xTconf_dir,3))

#######################finding absolute errors on training df models
mean(abs(trainDF$EXIT_SPEED - trainDF$exitVelo_RF))
```

```
[1] 4.016539
```

```
mean(abs(trainDF$EXIT_SPEED - trainDF$exitVelo_SVM))
```

```
[1] 1.266979
```

```
mean(abs(trainDF$EXIT_SPEED - trainDF$exitVelo_GAM))
```

```
[1] 10.11333
```

```
mean(abs(trainDF$EXIT_SPEED - trainDF$exitVelo_GLM))

[1] 10.11355

mean(abs(trainDF$EXIT_SPEED - trainDF$exitVelo_KNN))

[1] 8.328807

mean(abs(trainDF$ANGLE - trainDF$angle_RF))

[1] 8.190536

mean(abs(trainDF$ANGLE - trainDF$angle_SVM))

[1] 2.589948

mean(abs(trainDF$ANGLE - trainDF$angle_GAM))

[1] 19.04803

mean(abs(trainDF$ANGLE - trainDF$angle_GLM))

[1] 19.04803

mean(abs(trainDF$ANGLE - trainDF$angle_KNN))

[1] 16.74011

mean(abs(trainDF$DIRECTION - trainDF$direction_RF))

[1] 7.181192

mean(abs(trainDF$DIRECTION - trainDF$direction_SVM))

[1] 2.210109

mean(abs(trainDF$DIRECTION - trainDF$direction_GAM))

[1] 16.75261

mean(abs(trainDF$DIRECTION - trainDF$direction_GLM))

[1] 16.75257

mean(abs(trainDF$DIRECTION - trainDF$direction_KNN))

[1] 14.50776

######################
```

```
##################Testing Data
####gam
testDF <- testDF %>% mutate(exitVelo_GAM = round(gamEV[1] + gamEV[2]*RELEASE_SPEED + gamEV[3]*INDUCED_VERTICAL
                                                     gamEV[4]*HORIZONTAL_BREAK + gamEV[5]*HORIZONTAL_APPROACH_
                                                     gamEV[6]*OPS + gamEV[7]*Handedness, 3))

testDF <- testDF %>% mutate(angle_GAM = round(gamAng[1] + gamAng[2]*RELEASE_SPEED + gamAng[3]*PLATE_X +
                                                  gamAng[4]*PLATE_Z + gamAng[5]*INDUCED_VERTICAL_BREAK +
                                                  gamAng[6]*HORIZONTAL_BREAK + gamAng[7]*VERTICAL_APPROACH_ANG
                                                  gamAng[8]*HORIZONTAL_APPROACH_ANGLE +
                                                  gamAng[9]*OPS + gamAng[10]*Handedness, 3))

testDF <- testDF %>% mutate(direction_GAM = round(gamDir[1] + gamDir[2]*RELEASE_SPEED + gamDir[3]*PLATE_X +
                                                      gamDir[4]*INDUCED_VERTICAL_BREAK +
                                                      gamDir[5]*HORIZONTAL_BREAK + gamDir[6]*VERTICAL_APPROACH
                                                      gamDir[7]*HORIZONTAL_APPROACH_ANGLE +
                                                      gamDir[8]*OPS + gamDir[9]*Handedness, 3))

####glm
testDF <- testDF %>% mutate(exitVelo_GLM = round(evc[1] + evc[2]*RELEASE_SPEED + evc[3]*PLATE_X + evc[4]*PLATE
                                evc[5]*INDUCED_VERTICAL_BREAK + evc[6]*HORIZONTAL_BREAK +
                                evc[7]*VERTICAL_APPROACH_ANGLE +
                                evc[8]*HORIZONTAL_APPROACH_ANGLE + evc[9]*OPS + evc[10]*Handedness, 3))


testDF <- testDF %>% mutate(angle_GLM = round(ac[1] + ac[2]*RELEASE_SPEED + ac[3]*PLATE_X + ac[4]*PLATE_Z +
                             ac[5]*INDUCED_VERTICAL_BREAK + ac[6]*HORIZONTAL_BREAK +
                             ac[7]*VERTICAL_APPROACH_ANGLE +
                             ac[8]*HORIZONTAL_APPROACH_ANGLE + ac[9]*OPS + ac[10]*Handedness, 3))

testDF <- testDF %>% mutate(direction_GLM = round(dc[1] + dc[2]*RELEASE_SPEED + dc[3]*PLATE_X + dc[4]*PLATE_Z
                                 dc[5]*INDUCED_VERTICAL_BREAK + dc[6]*HORIZONTAL_BREAK +
                                 dc[7]*VERTICAL_APPROACH_ANGLE +
                                 dc[8]*HORIZONTAL_APPROACH_ANGLE + dc[9]*OPS + dc[10]*Handedness, 3))

###knn
testDF <- testDF %>% mutate(exitVelo_KNN = round(knnpred_y_EV,3))
testDF <- testDF %>% mutate(angle_KNN = round(knnpred_y_ang,3))
testDF <- testDF %>% mutate(direction_KNN = round(knnpred_y_dir,3))


head(trainDF)
```

```
  BATTER_UID    AVG    OBP    SLG VENUE_KEY OUTS BALLS STRIKES BATS_LEFT
1         29 0.2320 0.2860 0.2950      2852    1     2       1         1
2         87 0.2160 0.2820 0.3610      4271    1     2       0         1
3         20 0.2695 0.3390 0.3835      2528    0     3       2         0
4        147 0.2895 0.3655 0.4510      4670    1     1       2         0
5         99 0.2660 0.3285 0.3560      2852    2     2       2         0
6        110 0.2570 0.3365 0.4250      2852    2     1       2         0
  THROWS_LEFT PITCH_NUMBER RELEASE_SPEED    PLATE_X PLATE_Z
1           0            4      95.11150  0.7963360 1.35507
2           0            3      92.76369  0.4548490 2.59344
3           0            6      88.76340 -0.3001910 3.06310
4           1            4      81.78240 -0.1708880 1.84865
5           1            5      92.06150 -0.1243550 3.24001
6           0            4      81.60239  0.0411996 1.97743
  INDUCED_VERTICAL_BREAK HORIZONTAL_BREAK VERTICAL_APPROACH_ANGLE
1               17.01530        -4.657780                -6.54525
2               17.30840        -8.322809                -4.98211
```

```
3              2.46511       -20.656200                -5.81156
4             -3.59941        -7.826159                -8.56734
5             15.57420        10.426299                -4.67467
6             14.52030       -18.717300                -7.20663
  HORIZONTAL_APPROACH_ANGLE EXIT_SPEED      ANGLE  DIRECTION
1                  1.646740   83.65304 -14.851092  13.405146
2                  1.529110   95.66794   3.929680  21.932704
3                  0.266562   86.94758  22.556687  15.621360
4                 -2.952540   76.26321 -13.785541 -46.406194
5                 -1.051080   87.25558   1.316303  14.561501
6                  0.059810   82.83160  59.353564   1.017197
           EVENT_RESULT_KEY PITCH_RESULT_KEY PA X1B X2B X3B HR    OPS
1                 field_out           InPlay  1   0   0   0  0 0.5810
2                    single           InPlay  1   1   0   0  0 0.6430
3                 field_out           InPlay  1   0   0   0  0 0.7225
4 grounded_into_double_play           InPlay  1   0   0   0  0 0.8165
5                    single           InPlay  1   1   0   0  0 0.6845
6                 field_out           InPlay  1   0   0   0  0 0.7615
  Handedness exitVelo_RF angle_RF direction_RF exitVelo_SVM angle_SVM
1          1      83.799   -6.215       14.400       84.905   -12.358
2          1      93.515    9.437       17.158       94.418     6.427
3          0      88.297   17.467        9.507       88.198    20.066
4          1      81.476   -8.392      -24.479       77.517   -16.287
5          1      89.475   15.266        8.226       88.505     3.813
6          0      86.016   42.885        3.140       84.085    56.851
  direction_SVM exitVelo_GAM angle_GAM direction_GAM exitVelo_GLM angle_GLM
1        15.552       88.854     2.399        13.656       88.935     2.399
2        20.501       89.289    16.736        10.981       89.309    16.736
3        17.778       88.816    11.520        -2.975       88.798    11.520
4       -44.246       89.198     3.010        -1.830       89.233     3.010
5        12.408       89.425    21.826        -1.285       89.403    21.826
6        -1.138       88.336    19.072        -3.264       88.377    19.072
  direction_GLM exitVelo_KNN angle_KNN direction_KNN
1        13.630       90.318     7.715        12.695
2        10.980       91.891    17.399         4.056
3        -2.960       93.822    17.837        -7.282
4        -1.835       72.780   -16.943       -22.993
5        -1.265       99.492    21.210        -5.426
6        -3.273       83.394    37.113         9.861
```

```
kable(head(testDF))
```

BATAVGRB_BILLOVENUE_BASESKS_HRIKTS_HOTWOLL_NAMEPRADE_CHOICE_RIZONTAL_VERTICAL_BREAKHandedness_exitVelo_angle_GAMdirection_GLM_exitVelo_angle_GLM_KNN_direction_										
81	0.261.328.3625528 2	1	2	1	0	6	89.335802.5305040084988 0.3844000	- 4.47741957750	2.42159.0694	89.12921.61651389.04321.61649492.04017.60213.051
125	0.229.32515.4026831	1	1	1	0	3	87.97425952648066219336	- 1.30372055572	2.36758.9721	88.768380.90688.818380.92185.72120.084 2.762
21	0.274.5336.5427524 2	2	0	0	0	3	90.379702.7325401757994 0.0741844	- 1.61159580090	2.57133.0779	89.57820.276 89.56820.276 102.08851 3.839 5.041 5.028
73	0.289.0381.3747072 1	0	1	1	1	2	80.5115.650167524282639.462300	- 7.81318.0765851	0.755	87.35712.597 87.35912.597 88.23617.053 8.883 8.934 5.117
142	0.319.5360.5443572 0	0	1	1	0	2	84.0619.0780149340-18 11.446440 3.2285538 8.635422		3.91845.1804	88.53224410.73788.61672440.75989.09216.577 0.403
81	0.261.328.3625543 1	0	2	0	1	3	90.850476535901152839.363738	- 4.32805.2838810	0.694	89.48824.187594 89.52024.187612 95.07426.324 0.504