Analyzing 2022 NFL 4th Down Success by Team

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```
library(nflfastR)
library(tidyverse)
```

```
## -- Attaching packages --------------------------------------- tidyverse 1.3.2 --
## v ggplot2 3.4.0      v purrr   0.3.5
## v tibble  3.1.8      v dplyr   1.0.10
## v tidyr   1.2.1      v stringr 1.4.1
## v readr   2.1.3      v forcats 0.5.2
## -- Conflicts ------------------------------------------ tidyverse_conflicts() --
## x dplyr::filter() masks stats::filter()
## x dplyr::lag()    masks stats::lag()
```

```
library(ggrepel)
library(nflplotR)
library(knitr)
library(broom)
library(xgboost)
```

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

```
library(caTools)
library(caret)
```

```
## Loading required package: lattice
##
## Attaching package: 'caret'
##
## The following object is masked from 'package:purrr':
##
##     lift
```

```
data_99 <- nflfastR::load_pbp(1999) %>%
  mutate(year = 1999)
data_00 <- nflfastR::load_pbp(2000) %>%
  mutate(year = 2000)
data_01 <- nflfastR::load_pbp(2001) %>%
  mutate(year = 2001)
```

```r
data_02 <- nflfastR::load_pbp(2002) %>%
  mutate(year = 2002)
data_03 <- nflfastR::load_pbp(2003) %>%
  mutate(year = 2003)
data_04 <- nflfastR::load_pbp(2004) %>%
  mutate(year = 2004)
data_05 <- nflfastR::load_pbp(2005) %>%
  mutate(year = 2005)
data_06 <- nflfastR::load_pbp(2006) %>%
  mutate(year = 2006)
data_07 <- nflfastR::load_pbp(2007) %>%
  mutate(year = 2007)
data_08 <- nflfastR::load_pbp(2008) %>%
  mutate(year = 2008)
data_09 <- nflfastR::load_pbp(2009) %>%
  mutate(year = 2009)
data_10 <- nflfastR::load_pbp(2010) %>%
  mutate(year = 2010)
data_11 <- nflfastR::load_pbp(2011) %>%
  mutate(year = 2011)
data_12 <- nflfastR::load_pbp(2012) %>%
  mutate(year = 2012)
data_13 <- nflfastR::load_pbp(2013) %>%
  mutate(year = 2013)
data_14 <- nflfastR::load_pbp(2014) %>%
  mutate(year = 2014)
data_15 <- nflfastR::load_pbp(2015) %>%
  mutate(year = 2015)
data_16 <- nflfastR::load_pbp(2016) %>%
  mutate(year = 2016)
data_17 <- nflfastR::load_pbp(2017) %>%
  mutate(year = 2017)
data_18 <- nflfastR::load_pbp(2018) %>%
  mutate(year = 2018)
data_19 <- nflfastR::load_pbp(2019) %>%
  mutate(year = 2019)
data_20 <- nflfastR::load_pbp(2020) %>%
  mutate(year = 2020)
data_21 <- nflfastR::load_pbp(2021) %>%
  mutate(year = 2021)
data_22 <- nflfastR::load_pbp(2022) %>%
  mutate(year = 2022)
data <- rbind(data_99, data_00, data_01, data_02, data_03, data_04, data_05,
              data_06, data_07, data_08, data_09, data_10, data_11, data_12,
              data_13, data_14, data_15, data_16, data_17, data_18, data_19,
              data_20, data_21, data_22)
data_main <- data %>%
  select(yardline_100, game_seconds_remaining, qtr,
         down, ydstogo, score_differential, no_score_prob,
         opp_fg_prob, opp_safety_prob, opp_td_prob, fg_prob, safety_prob,
         td_prob, wp, fourth_down_converted, fourth_down_failed,
         posteam_timeouts_remaining, defteam_timeouts_remaining, ep, epa, year,
         week, posteam, posteam_type, play_type, wpa, total_home_epa, total_away_epa) %>%
```

```
  filter(down == 4) %>%
  mutate(play_type = as.factor(ifelse(play_type == "run" | play_type == "pass", "go", play_type))) %>%
  drop_na(play_type, wpa) %>%
  filter(play_type %in% c("go", "field_goal", "punt"))

run_pass <- data %>%
  select(yardline_100, game_seconds_remaining, qtr,
         down, ydstogo, score_differential, no_score_prob,
         opp_fg_prob, opp_safety_prob, opp_td_prob, fg_prob, safety_prob,
         td_prob, wp, fourth_down_converted, fourth_down_failed,
         posteam_timeouts_remaining, defteam_timeouts_remaining, ep, epa, year,
         week, posteam, posteam_type, play_type, wpa, total_home_epa, total_away_epa) %>%
  filter(down == 4,
         play_type %in% c("run", "pass")) %>%
  drop_na(wpa)
```

```
data_main %>%
  group_by(play_type) %>%
  summarize(count = n()) %>%
  kable()
```

play_type	count
field_goal	21970
go	12629
punt	58803

```
punt_data <- data_main %>%
  filter(play_type == "punt") %>%
  select(-c(qtr, down, fourth_down_converted, fourth_down_failed, ep, epa, year,
            week, posteam, play_type, posteam_type)) %>%
  select(wpa, everything())
kick_data <- data_main %>%
  filter(play_type == "field_goal") %>%
  select(-c(qtr, down, fourth_down_converted, fourth_down_failed, ep, epa, year,
            week, posteam, play_type, posteam_type)) %>%
  select(wpa, everything())
go_data <- data_main %>%
  filter(play_type == "go") %>%
  select(-c(qtr, down, fourth_down_converted, fourth_down_failed, ep, epa, year,
            week, posteam, play_type, posteam_type)) %>%
  select(wpa, everything())
```

```
lm1_punt <- lm(wpa ~ ., data = punt_data)
tidy(lm1_punt)
```

```
## # A tibble: 17 x 5
##    term                  estimate std.error statistic  p.value
##    <chr>                    <dbl>     <dbl>     <dbl>    <dbl>
## 1 (Intercept)           -4.08e+3   6.08e+3    -0.671 5.02e-  1
## 2 yardline_100           4.74e-4   3.25e-5    14.6   5.40e- 48
```

```
##  3 game_seconds_remaining      1.21e-6   1.83e-7    6.64  3.20e- 11
##  4 ydstogo                     8.65e-4   3.23e-5   26.8   6.01e-157
##  5 score_differential          2.18e-3   4.30e-5   50.7   0
##  6 no_score_prob               4.08e+3   6.08e+3    0.671 5.02e-  1
##  7 opp_fg_prob                 4.08e+3   6.08e+3    0.671 5.02e-  1
##  8 opp_safety_prob             4.08e+3   6.08e+3    0.671 5.02e-  1
##  9 opp_td_prob                 4.08e+3   6.08e+3    0.671 5.02e-  1
## 10 fg_prob                     4.08e+3   6.08e+3    0.671 5.02e-  1
## 11 safety_prob                 4.08e+3   6.08e+3    0.671 5.02e-  1
## 12 td_prob                     4.08e+3   6.08e+3    0.671 5.02e-  1
## 13 wp                         -8.75e-2   1.60e-3  -54.6   0
## 14 posteam_timeouts_remaining -3.60e-3   3.12e-4  -11.5   1.10e- 30
## 15 defteam_timeouts_remaining -5.34e-3   2.98e-4  -17.9   1.75e- 71
## 16 total_home_epa             -7.91e-5   2.24e-4   -0.353 7.24e-  1
## 17 total_away_epa             -9.46e-5   2.23e-4   -0.424 6.72e-  1
```

summary(lm1_punt)

```
##
## Call:
## lm(formula = wpa ~ ., data = punt_data)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.59040 -0.01612 -0.00047  0.01617  0.92918
##
## Coefficients:
##                              Estimate Std. Error t value Pr(>|t|)
## (Intercept)                -4.079e+03  6.082e+03  -0.671    0.502
## yardline_100                4.742e-04  3.255e-05  14.569  < 2e-16 ***
## game_seconds_remaining      1.212e-06  1.826e-07   6.638  3.2e-11 ***
## ydstogo                     8.647e-04  3.230e-05  26.772  < 2e-16 ***
## score_differential          2.181e-03  4.304e-05  50.680  < 2e-16 ***
## no_score_prob               4.079e+03  6.082e+03   0.671    0.502
## opp_fg_prob                 4.079e+03  6.082e+03   0.671    0.502
## opp_safety_prob             4.079e+03  6.082e+03   0.671    0.502
## opp_td_prob                 4.079e+03  6.082e+03   0.671    0.502
## fg_prob                     4.079e+03  6.082e+03   0.671    0.502
## safety_prob                 4.080e+03  6.082e+03   0.671    0.502
## td_prob                     4.079e+03  6.082e+03   0.671    0.502
## wp                         -8.747e-02  1.602e-03 -54.587  < 2e-16 ***
## posteam_timeouts_remaining -3.599e-03  3.124e-04 -11.522  < 2e-16 ***
## defteam_timeouts_remaining -5.336e-03  2.980e-04 -17.903  < 2e-16 ***
## total_home_epa             -7.907e-05  2.238e-04  -0.353    0.724
## total_away_epa             -9.461e-05  2.233e-04  -0.424    0.672
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.0409 on 58786 degrees of freedom
## Multiple R-squared:  0.08765,    Adjusted R-squared:  0.0874
## F-statistic:   353 on 16 and 58786 DF,  p-value: < 2.2e-16
```

```
set.seed(12321)
sample <- sample(c(TRUE, FALSE), nrow(punt_data), replace = TRUE, prob = c(0.7, 0.3))
punt_data_train <- punt_data[sample, ]
punt_data_test <- punt_data[!sample, ]
punt_train_x <- data.matrix(punt_data_train[, -1])
punt_train_y <- punt_data_train$wpa
punt_test_x <- data.matrix(punt_data_test[, -1])
punt_test_y <- punt_data_test$wpa
punt_xgb_train = xgb.DMatrix(data = punt_train_x, label = punt_train_y)
punt_xgb_test = xgb.DMatrix(data = punt_test_x, label = punt_test_y)
punt_watchlist = list(train=punt_xgb_train, test=punt_xgb_test)
punt_model = xgb.train(data = punt_xgb_train, max.depth = 3, watchlist=punt_watchlist, nrounds = 1000)
```

```
## [1]   train-rmse:0.352630 test-rmse:0.352566
## [2]   train-rmse:0.248226 test-rmse:0.248238
## [3]   train-rmse:0.175774 test-rmse:0.175892
## [4]   train-rmse:0.125823 test-rmse:0.126048
## [5]   train-rmse:0.091562 test-rmse:0.091832
## [6]   train-rmse:0.068947 test-rmse:0.069358
## [7]   train-rmse:0.054436 test-rmse:0.054980
## [8]   train-rmse:0.045639 test-rmse:0.046327
## [9]   train-rmse:0.040575 test-rmse:0.041411
## [10]  train-rmse:0.037721 test-rmse:0.038672
## [11]  train-rmse:0.036061 test-rmse:0.037061
## [12]  train-rmse:0.035130 test-rmse:0.036185
## [13]  train-rmse:0.034040 test-rmse:0.035025
## [14]  train-rmse:0.033693 test-rmse:0.034723
## [15]  train-rmse:0.033495 test-rmse:0.034553
## [16]  train-rmse:0.033333 test-rmse:0.034434
## [17]  train-rmse:0.033232 test-rmse:0.034342
## [18]  train-rmse:0.033163 test-rmse:0.034307
## [19]  train-rmse:0.032982 test-rmse:0.034132
## [20]  train-rmse:0.032911 test-rmse:0.034086
## [21]  train-rmse:0.032839 test-rmse:0.034009
## [22]  train-rmse:0.032762 test-rmse:0.033953
## [23]  train-rmse:0.032702 test-rmse:0.033899
## [24]  train-rmse:0.032528 test-rmse:0.033752
## [25]  train-rmse:0.032145 test-rmse:0.033444
## [26]  train-rmse:0.031542 test-rmse:0.032887
## [27]  train-rmse:0.031361 test-rmse:0.032686
## [28]  train-rmse:0.031112 test-rmse:0.032403
## [29]  train-rmse:0.030999 test-rmse:0.032300
## [30]  train-rmse:0.030741 test-rmse:0.032063
## [31]  train-rmse:0.030661 test-rmse:0.031981
## [32]  train-rmse:0.030616 test-rmse:0.031950
## [33]  train-rmse:0.030571 test-rmse:0.031916
## [34]  train-rmse:0.030497 test-rmse:0.031845
## [35]  train-rmse:0.030165 test-rmse:0.031518
## [36]  train-rmse:0.030140 test-rmse:0.031489
## [37]  train-rmse:0.030109 test-rmse:0.031465
## [38]  train-rmse:0.030058 test-rmse:0.031405
## [39]  train-rmse:0.030027 test-rmse:0.031377
## [40]  train-rmse:0.029997 test-rmse:0.031354
```

```
## [41]  train-rmse:0.029759 test-rmse:0.031189
## [42]  train-rmse:0.029557 test-rmse:0.031005
## [43]  train-rmse:0.029492 test-rmse:0.030945
## [44]  train-rmse:0.029346 test-rmse:0.030812
## [45]  train-rmse:0.029309 test-rmse:0.030789
## [46]  train-rmse:0.029291 test-rmse:0.030787
## [47]  train-rmse:0.029245 test-rmse:0.030762
## [48]  train-rmse:0.029079 test-rmse:0.030633
## [49]  train-rmse:0.028948 test-rmse:0.030538
## [50]  train-rmse:0.028904 test-rmse:0.030492
## [51]  train-rmse:0.028889 test-rmse:0.030477
## [52]  train-rmse:0.028810 test-rmse:0.030414
## [53]  train-rmse:0.028683 test-rmse:0.030257
## [54]  train-rmse:0.028660 test-rmse:0.030235
## [55]  train-rmse:0.028624 test-rmse:0.030202
## [56]  train-rmse:0.028590 test-rmse:0.030171
## [57]  train-rmse:0.028527 test-rmse:0.030145
## [58]  train-rmse:0.028432 test-rmse:0.030036
## [59]  train-rmse:0.028347 test-rmse:0.029972
## [60]  train-rmse:0.028179 test-rmse:0.029830
## [61]  train-rmse:0.028135 test-rmse:0.029780
## [62]  train-rmse:0.028102 test-rmse:0.029739
## [63]  train-rmse:0.028082 test-rmse:0.029737
## [64]  train-rmse:0.028068 test-rmse:0.029730
## [65]  train-rmse:0.028047 test-rmse:0.029710
## [66]  train-rmse:0.028013 test-rmse:0.029684
## [67]  train-rmse:0.028002 test-rmse:0.029682
## [68]  train-rmse:0.027956 test-rmse:0.029646
## [69]  train-rmse:0.027947 test-rmse:0.029637
## [70]  train-rmse:0.027902 test-rmse:0.029605
## [71]  train-rmse:0.027873 test-rmse:0.029577
## [72]  train-rmse:0.027807 test-rmse:0.029523
## [73]  train-rmse:0.027786 test-rmse:0.029509
## [74]  train-rmse:0.027768 test-rmse:0.029490
## [75]  train-rmse:0.027741 test-rmse:0.029469
## [76]  train-rmse:0.027702 test-rmse:0.029434
## [77]  train-rmse:0.027688 test-rmse:0.029421
## [78]  train-rmse:0.027669 test-rmse:0.029405
## [79]  train-rmse:0.027624 test-rmse:0.029371
## [80]  train-rmse:0.027560 test-rmse:0.029337
## [81]  train-rmse:0.027536 test-rmse:0.029318
## [82]  train-rmse:0.027508 test-rmse:0.029289
## [83]  train-rmse:0.027496 test-rmse:0.029280
## [84]  train-rmse:0.027444 test-rmse:0.029249
## [85]  train-rmse:0.027423 test-rmse:0.029239
## [86]  train-rmse:0.027416 test-rmse:0.029239
## [87]  train-rmse:0.027409 test-rmse:0.029239
## [88]  train-rmse:0.027401 test-rmse:0.029237
## [89]  train-rmse:0.027392 test-rmse:0.029234
## [90]  train-rmse:0.027384 test-rmse:0.029227
## [91]  train-rmse:0.027315 test-rmse:0.029163
## [92]  train-rmse:0.027240 test-rmse:0.029100
## [93]  train-rmse:0.027187 test-rmse:0.029063
## [94]  train-rmse:0.027131 test-rmse:0.029024
```

```
## [95] train-rmse:0.027051 test-rmse:0.028960
## [96] train-rmse:0.027014 test-rmse:0.028929
## [97] train-rmse:0.026981 test-rmse:0.028897
## [98] train-rmse:0.026956 test-rmse:0.028894
## [99] train-rmse:0.026947 test-rmse:0.028887
## [100]     train-rmse:0.026920 test-rmse:0.028868
## [101]     train-rmse:0.026903 test-rmse:0.028854
## [102]     train-rmse:0.026893 test-rmse:0.028853
## [103]     train-rmse:0.026881 test-rmse:0.028852
## [104]     train-rmse:0.026877 test-rmse:0.028856
## [105]     train-rmse:0.026856 test-rmse:0.028831
## [106]     train-rmse:0.026843 test-rmse:0.028829
## [107]     train-rmse:0.026819 test-rmse:0.028807
## [108]     train-rmse:0.026766 test-rmse:0.028736
## [109]     train-rmse:0.026738 test-rmse:0.028703
## [110]     train-rmse:0.026696 test-rmse:0.028674
## [111]     train-rmse:0.026676 test-rmse:0.028658
## [112]     train-rmse:0.026657 test-rmse:0.028634
## [113]     train-rmse:0.026625 test-rmse:0.028615
## [114]     train-rmse:0.026602 test-rmse:0.028592
## [115]     train-rmse:0.026558 test-rmse:0.028566
## [116]     train-rmse:0.026550 test-rmse:0.028558
## [117]     train-rmse:0.026530 test-rmse:0.028547
## [118]     train-rmse:0.026484 test-rmse:0.028503
## [119]     train-rmse:0.026421 test-rmse:0.028469
## [120]     train-rmse:0.026335 test-rmse:0.028378
## [121]     train-rmse:0.026299 test-rmse:0.028349
## [122]     train-rmse:0.026283 test-rmse:0.028335
## [123]     train-rmse:0.026270 test-rmse:0.028324
## [124]     train-rmse:0.026217 test-rmse:0.028269
## [125]     train-rmse:0.026165 test-rmse:0.028231
## [126]     train-rmse:0.026136 test-rmse:0.028217
## [127]     train-rmse:0.026103 test-rmse:0.028197
## [128]     train-rmse:0.026088 test-rmse:0.028183
## [129]     train-rmse:0.026074 test-rmse:0.028175
## [130]     train-rmse:0.026026 test-rmse:0.028125
## [131]     train-rmse:0.025995 test-rmse:0.028098
## [132]     train-rmse:0.025973 test-rmse:0.028085
## [133]     train-rmse:0.025960 test-rmse:0.028075
## [134]     train-rmse:0.025945 test-rmse:0.028066
## [135]     train-rmse:0.025943 test-rmse:0.028072
## [136]     train-rmse:0.025938 test-rmse:0.028070
## [137]     train-rmse:0.025920 test-rmse:0.028057
## [138]     train-rmse:0.025696 test-rmse:0.027837
## [139]     train-rmse:0.025665 test-rmse:0.027811
## [140]     train-rmse:0.025626 test-rmse:0.027789
## [141]     train-rmse:0.025601 test-rmse:0.027777
## [142]     train-rmse:0.025545 test-rmse:0.027737
## [143]     train-rmse:0.025528 test-rmse:0.027710
## [144]     train-rmse:0.025489 test-rmse:0.027700
## [145]     train-rmse:0.025466 test-rmse:0.027679
## [146]     train-rmse:0.025456 test-rmse:0.027672
## [147]     train-rmse:0.025442 test-rmse:0.027666
## [148]     train-rmse:0.025408 test-rmse:0.027627
```

```
## [149]    train-rmse:0.025398 test-rmse:0.027622
## [150]    train-rmse:0.025379 test-rmse:0.027615
## [151]    train-rmse:0.025360 test-rmse:0.027628
## [152]    train-rmse:0.025348 test-rmse:0.027620
## [153]    train-rmse:0.025313 test-rmse:0.027586
## [154]    train-rmse:0.025270 test-rmse:0.027561
## [155]    train-rmse:0.025238 test-rmse:0.027538
## [156]    train-rmse:0.025216 test-rmse:0.027525
## [157]    train-rmse:0.025206 test-rmse:0.027508
## [158]    train-rmse:0.025192 test-rmse:0.027502
## [159]    train-rmse:0.025163 test-rmse:0.027473
## [160]    train-rmse:0.025157 test-rmse:0.027474
## [161]    train-rmse:0.025147 test-rmse:0.027469
## [162]    train-rmse:0.025143 test-rmse:0.027475
## [163]    train-rmse:0.025141 test-rmse:0.027477
## [164]    train-rmse:0.025137 test-rmse:0.027480
## [165]    train-rmse:0.025123 test-rmse:0.027473
## [166]    train-rmse:0.025110 test-rmse:0.027468
## [167]    train-rmse:0.025105 test-rmse:0.027466
## [168]    train-rmse:0.025091 test-rmse:0.027462
## [169]    train-rmse:0.025078 test-rmse:0.027449
## [170]    train-rmse:0.025056 test-rmse:0.027432
## [171]    train-rmse:0.025039 test-rmse:0.027413
## [172]    train-rmse:0.025010 test-rmse:0.027373
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## [801]     train-rmse:0.018351 test-rmse:0.024235
## [802]     train-rmse:0.018344 test-rmse:0.024236
## [803]     train-rmse:0.018338 test-rmse:0.024235
## [804]     train-rmse:0.018337 test-rmse:0.024234
## [805]     train-rmse:0.018333 test-rmse:0.024228
## [806]     train-rmse:0.018330 test-rmse:0.024230
## [807]     train-rmse:0.018323 test-rmse:0.024223
## [808]     train-rmse:0.018311 test-rmse:0.024214
## [809]     train-rmse:0.018303 test-rmse:0.024211
## [810]     train-rmse:0.018288 test-rmse:0.024199
## [811]     train-rmse:0.018282 test-rmse:0.024195
## [812]     train-rmse:0.018273 test-rmse:0.024197
## [813]     train-rmse:0.018267 test-rmse:0.024197
## [814]     train-rmse:0.018266 test-rmse:0.024197
## [815]     train-rmse:0.018261 test-rmse:0.024197
## [816]     train-rmse:0.018257 test-rmse:0.024196
## [817]     train-rmse:0.018254 test-rmse:0.024195
## [818]     train-rmse:0.018248 test-rmse:0.024193
## [819]     train-rmse:0.018241 test-rmse:0.024190
## [820]     train-rmse:0.018224 test-rmse:0.024171
## [821]     train-rmse:0.018220 test-rmse:0.024169
## [822]     train-rmse:0.018217 test-rmse:0.024167
## [823]     train-rmse:0.018215 test-rmse:0.024165
## [824]     train-rmse:0.018212 test-rmse:0.024166
## [825]     train-rmse:0.018209 test-rmse:0.024166
## [826]     train-rmse:0.018205 test-rmse:0.024164
## [827]     train-rmse:0.018202 test-rmse:0.024165
## [828]     train-rmse:0.018197 test-rmse:0.024166
## [829]     train-rmse:0.018194 test-rmse:0.024166
## [830]     train-rmse:0.018193 test-rmse:0.024165
## [831]     train-rmse:0.018180 test-rmse:0.024162
## [832]     train-rmse:0.018112 test-rmse:0.024084
## [833]     train-rmse:0.018108 test-rmse:0.024085
## [834]     train-rmse:0.018096 test-rmse:0.024081
## [835]     train-rmse:0.018090 test-rmse:0.024079
## [836]     train-rmse:0.018084 test-rmse:0.024075
## [837]     train-rmse:0.018080 test-rmse:0.024075
## [838]     train-rmse:0.018075 test-rmse:0.024073
## [839]     train-rmse:0.018068 test-rmse:0.024074
## [840]     train-rmse:0.018066 test-rmse:0.024072
## [841]     train-rmse:0.018061 test-rmse:0.024072
## [842]     train-rmse:0.018056 test-rmse:0.024072
## [843]     train-rmse:0.018046 test-rmse:0.024071
## [844]     train-rmse:0.018041 test-rmse:0.024069
## [845]     train-rmse:0.018035 test-rmse:0.024064
## [846]     train-rmse:0.018031 test-rmse:0.024062
## [847]     train-rmse:0.018028 test-rmse:0.024063
## [848]     train-rmse:0.018028 test-rmse:0.024064
## [849]     train-rmse:0.018023 test-rmse:0.024065
## [850]     train-rmse:0.018019 test-rmse:0.024063
```

```
## [851]    train-rmse:0.018016 test-rmse:0.024064
## [852]    train-rmse:0.018008 test-rmse:0.024069
## [853]    train-rmse:0.018005 test-rmse:0.024069
## [854]    train-rmse:0.018002 test-rmse:0.024073
## [855]    train-rmse:0.018000 test-rmse:0.024073
## [856]    train-rmse:0.017993 test-rmse:0.024074
## [857]    train-rmse:0.017989 test-rmse:0.024072
## [858]    train-rmse:0.017985 test-rmse:0.024071
## [859]    train-rmse:0.017975 test-rmse:0.024071
## [860]    train-rmse:0.017972 test-rmse:0.024071
## [861]    train-rmse:0.017969 test-rmse:0.024071
## [862]    train-rmse:0.017964 test-rmse:0.024071
## [863]    train-rmse:0.017950 test-rmse:0.024061
## [864]    train-rmse:0.017944 test-rmse:0.024058
## [865]    train-rmse:0.017938 test-rmse:0.024058
## [866]    train-rmse:0.017931 test-rmse:0.024052
## [867]    train-rmse:0.017897 test-rmse:0.024027
## [868]    train-rmse:0.017882 test-rmse:0.024023
## [869]    train-rmse:0.017877 test-rmse:0.024022
## [870]    train-rmse:0.017837 test-rmse:0.024004
## [871]    train-rmse:0.017835 test-rmse:0.024002
## [872]    train-rmse:0.017828 test-rmse:0.024000
## [873]    train-rmse:0.017814 test-rmse:0.023999
## [874]    train-rmse:0.017809 test-rmse:0.023998
## [875]    train-rmse:0.017806 test-rmse:0.023996
## [876]    train-rmse:0.017804 test-rmse:0.023995
## [877]    train-rmse:0.017800 test-rmse:0.023996
## [878]    train-rmse:0.017756 test-rmse:0.023945
## [879]    train-rmse:0.017752 test-rmse:0.023946
## [880]    train-rmse:0.017747 test-rmse:0.023950
## [881]    train-rmse:0.017742 test-rmse:0.023953
## [882]    train-rmse:0.017740 test-rmse:0.023951
## [883]    train-rmse:0.017738 test-rmse:0.023949
## [884]    train-rmse:0.017734 test-rmse:0.023945
## [885]    train-rmse:0.017731 test-rmse:0.023948
## [886]    train-rmse:0.017728 test-rmse:0.023949
## [887]    train-rmse:0.017721 test-rmse:0.023952
## [888]    train-rmse:0.017717 test-rmse:0.023951
## [889]    train-rmse:0.017705 test-rmse:0.023950
## [890]    train-rmse:0.017698 test-rmse:0.023948
## [891]    train-rmse:0.017693 test-rmse:0.023949
## [892]    train-rmse:0.017690 test-rmse:0.023950
## [893]    train-rmse:0.017685 test-rmse:0.023954
## [894]    train-rmse:0.017683 test-rmse:0.023953
## [895]    train-rmse:0.017681 test-rmse:0.023951
## [896]    train-rmse:0.017679 test-rmse:0.023951
## [897]    train-rmse:0.017678 test-rmse:0.023953
## [898]    train-rmse:0.017673 test-rmse:0.023953
## [899]    train-rmse:0.017672 test-rmse:0.023952
## [900]    train-rmse:0.017670 test-rmse:0.023952
## [901]    train-rmse:0.017667 test-rmse:0.023952
## [902]    train-rmse:0.017659 test-rmse:0.023951
## [903]    train-rmse:0.017655 test-rmse:0.023951
## [904]    train-rmse:0.017651 test-rmse:0.023952
```

```
## [905]    train-rmse:0.017648 test-rmse:0.023952
## [906]    train-rmse:0.017647 test-rmse:0.023951
## [907]    train-rmse:0.017642 test-rmse:0.023946
## [908]    train-rmse:0.017639 test-rmse:0.023945
## [909]    train-rmse:0.017636 test-rmse:0.023942
## [910]    train-rmse:0.017632 test-rmse:0.023945
## [911]    train-rmse:0.017626 test-rmse:0.023951
## [912]    train-rmse:0.017620 test-rmse:0.023951
## [913]    train-rmse:0.017615 test-rmse:0.023952
## [914]    train-rmse:0.017612 test-rmse:0.023952
## [915]    train-rmse:0.017610 test-rmse:0.023951
## [916]    train-rmse:0.017608 test-rmse:0.023951
## [917]    train-rmse:0.017605 test-rmse:0.023952
## [918]    train-rmse:0.017600 test-rmse:0.023951
## [919]    train-rmse:0.017597 test-rmse:0.023952
## [920]    train-rmse:0.017594 test-rmse:0.023951
## [921]    train-rmse:0.017591 test-rmse:0.023950
## [922]    train-rmse:0.017586 test-rmse:0.023950
## [923]    train-rmse:0.017584 test-rmse:0.023949
## [924]    train-rmse:0.017580 test-rmse:0.023945
## [925]    train-rmse:0.017578 test-rmse:0.023946
## [926]    train-rmse:0.017576 test-rmse:0.023946
## [927]    train-rmse:0.017572 test-rmse:0.023946
## [928]    train-rmse:0.017566 test-rmse:0.023949
## [929]    train-rmse:0.017561 test-rmse:0.023951
## [930]    train-rmse:0.017552 test-rmse:0.023950
## [931]    train-rmse:0.017550 test-rmse:0.023950
## [932]    train-rmse:0.017550 test-rmse:0.023951
## [933]    train-rmse:0.017546 test-rmse:0.023951
## [934]    train-rmse:0.017544 test-rmse:0.023950
## [935]    train-rmse:0.017539 test-rmse:0.023948
## [936]    train-rmse:0.017533 test-rmse:0.023947
## [937]    train-rmse:0.017525 test-rmse:0.023948
## [938]    train-rmse:0.017519 test-rmse:0.023950
## [939]    train-rmse:0.017511 test-rmse:0.023950
## [940]    train-rmse:0.017507 test-rmse:0.023950
## [941]    train-rmse:0.017493 test-rmse:0.023937
## [942]    train-rmse:0.017489 test-rmse:0.023936
## [943]    train-rmse:0.017479 test-rmse:0.023938
## [944]    train-rmse:0.017475 test-rmse:0.023939
## [945]    train-rmse:0.017471 test-rmse:0.023939
## [946]    train-rmse:0.017467 test-rmse:0.023940
## [947]    train-rmse:0.017464 test-rmse:0.023939
## [948]    train-rmse:0.017458 test-rmse:0.023937
## [949]    train-rmse:0.017454 test-rmse:0.023936
## [950]    train-rmse:0.017446 test-rmse:0.023942
## [951]    train-rmse:0.017443 test-rmse:0.023939
## [952]    train-rmse:0.017440 test-rmse:0.023939
## [953]    train-rmse:0.017437 test-rmse:0.023938
## [954]    train-rmse:0.017429 test-rmse:0.023933
## [955]    train-rmse:0.017425 test-rmse:0.023932
## [956]    train-rmse:0.017422 test-rmse:0.023933
## [957]    train-rmse:0.017414 test-rmse:0.023933
## [958]    train-rmse:0.017407 test-rmse:0.023931
```

```
## [959]     train-rmse:0.017403 test-rmse:0.023932
## [960]     train-rmse:0.017394 test-rmse:0.023937
## [961]     train-rmse:0.017390 test-rmse:0.023936
## [962]     train-rmse:0.017387 test-rmse:0.023936
## [963]     train-rmse:0.017386 test-rmse:0.023936
## [964]     train-rmse:0.017382 test-rmse:0.023933
## [965]     train-rmse:0.017378 test-rmse:0.023936
## [966]     train-rmse:0.017376 test-rmse:0.023938
## [967]     train-rmse:0.017375 test-rmse:0.023937
## [968]     train-rmse:0.017370 test-rmse:0.023936
## [969]     train-rmse:0.017367 test-rmse:0.023935
## [970]     train-rmse:0.017363 test-rmse:0.023934
## [971]     train-rmse:0.017355 test-rmse:0.023936
## [972]     train-rmse:0.017355 test-rmse:0.023936
## [973]     train-rmse:0.017353 test-rmse:0.023937
## [974]     train-rmse:0.017352 test-rmse:0.023938
## [975]     train-rmse:0.017344 test-rmse:0.023941
## [976]     train-rmse:0.017338 test-rmse:0.023942
## [977]     train-rmse:0.017336 test-rmse:0.023943
## [978]     train-rmse:0.017333 test-rmse:0.023942
## [979]     train-rmse:0.017331 test-rmse:0.023942
## [980]     train-rmse:0.017327 test-rmse:0.023941
## [981]     train-rmse:0.017319 test-rmse:0.023930
## [982]     train-rmse:0.017302 test-rmse:0.023923
## [983]     train-rmse:0.017298 test-rmse:0.023923
## [984]     train-rmse:0.017288 test-rmse:0.023921
## [985]     train-rmse:0.017284 test-rmse:0.023919
## [986]     train-rmse:0.017274 test-rmse:0.023919
## [987]     train-rmse:0.017250 test-rmse:0.023901
## [988]     train-rmse:0.017246 test-rmse:0.023900
## [989]     train-rmse:0.017243 test-rmse:0.023900
## [990]     train-rmse:0.017239 test-rmse:0.023899
## [991]     train-rmse:0.017236 test-rmse:0.023900
## [992]     train-rmse:0.017231 test-rmse:0.023900
## [993]     train-rmse:0.017228 test-rmse:0.023900
## [994]     train-rmse:0.017225 test-rmse:0.023900
## [995]     train-rmse:0.017222 test-rmse:0.023898
## [996]     train-rmse:0.017217 test-rmse:0.023899
## [997]     train-rmse:0.017217 test-rmse:0.023900
## [998]     train-rmse:0.017215 test-rmse:0.023900
## [999]     train-rmse:0.017210 test-rmse:0.023905
## [1000]    train-rmse:0.017202 test-rmse:0.023906
```

```r
punt_model_xgboost = xgboost(data = punt_xgb_train, max.depth = 3, nrounds = 995, verbose = 0)
summary(punt_model_xgboost)
```

```
##                 Length  Class              Mode
## handle               1 xgb.Booster.handle externalptr
## raw            1154223 -none-             raw
## niter                1 -none-             numeric
## evaluation_log       2 data.table         list
## call                14 -none-             call
## params               2 -none-             list
## callbacks            1 -none-             list
```

```
## feature_names        16 -none-           character
## nfeatures              1 -none-           numeric
```
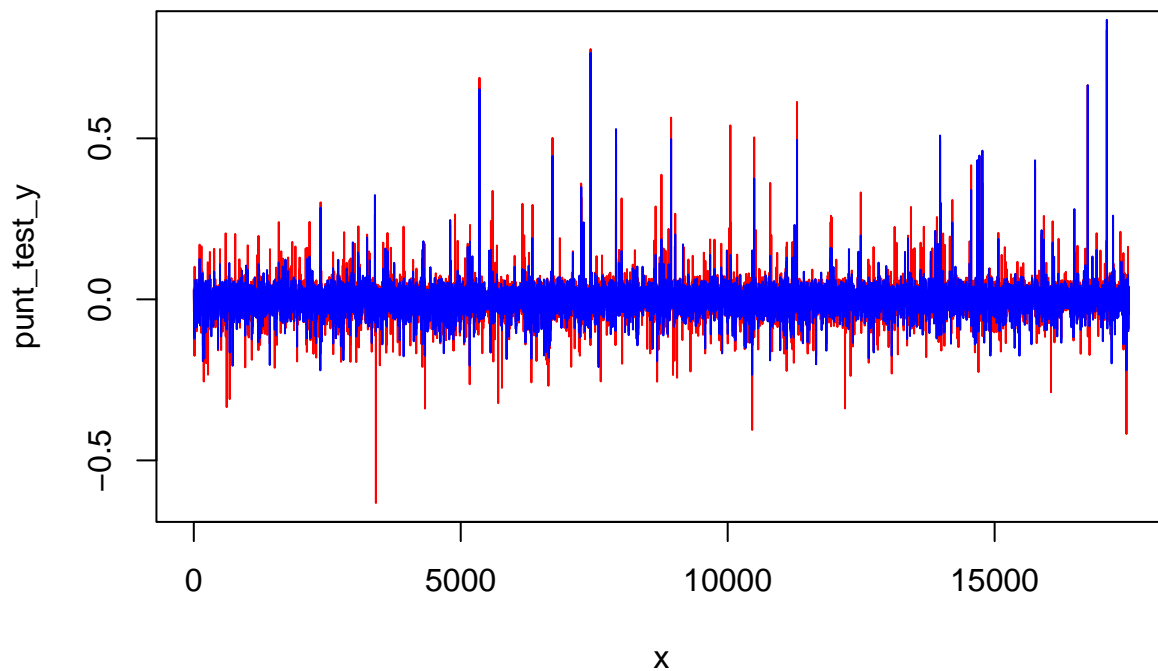
```
punt_pred_y = predict(punt_model_xgboost, punt_xgb_test)
mean((punt_test_y - punt_pred_y)^2)
```

```
## [1] 0.0005711103
```

```
RMSE(punt_test_y, punt_pred_y)
```

```
## [1] 0.02389792
```

```
y_punt_test_mean = mean(punt_test_y)
tss = sum((punt_test_y - y_punt_test_mean)^2)
rss = sum(resid(punt_model_xgboost)^2)
x = 1:length(punt_test_y)
plot(x, punt_test_y, col = "red", type = "l")
lines(x, punt_pred_y, col = "blue", type = "l")
```



```
set.seed(12321)
sample <- sample(c(TRUE, FALSE), nrow(kick_data), replace = TRUE, prob = c(0.7, 0.3))
kick_data_train <- kick_data[sample, ]
kick_data_test <- kick_data[!sample, ]
```

```r
kick_train_x <- data.matrix(kick_data_train[, -1])
kick_train_y <- kick_data_train$wpa
kick_test_x <- data.matrix(kick_data_test[, -1])
kick_test_y <- kick_data_test$wpa
kick_xgb_train = xgb.DMatrix(data = kick_train_x, label = kick_train_y)
kick_xgb_test = xgb.DMatrix(data = kick_test_x, label = kick_test_y)
kick_watchlist = list(train=kick_xgb_train, test=kick_xgb_test)
kick_model = xgb.train(data = kick_xgb_train, max.depth = 3, watchlist=kick_watchlist, nrounds = 1000)
```

```
## [1]   train-rmse:0.355748 test-rmse:0.355403
## [2]   train-rmse:0.252796 test-rmse:0.252410
## [3]   train-rmse:0.182129 test-rmse:0.181820
## [4]   train-rmse:0.134534 test-rmse:0.134345
## [5]   train-rmse:0.103057 test-rmse:0.103087
## [6]   train-rmse:0.083188 test-rmse:0.083415
## [7]   train-rmse:0.071584 test-rmse:0.072040
## [8]   train-rmse:0.065035 test-rmse:0.065701
## [9]   train-rmse:0.061555 test-rmse:0.062441
## [10] train-rmse:0.059196 test-rmse:0.060353
## [11] train-rmse:0.058200 test-rmse:0.059478
## [12] train-rmse:0.057382 test-rmse:0.058857
## [13] train-rmse:0.056859 test-rmse:0.058400
## [14] train-rmse:0.056380 test-rmse:0.058000
## [15] train-rmse:0.056154 test-rmse:0.057878
## [16] train-rmse:0.056067 test-rmse:0.057914
## [17] train-rmse:0.055668 test-rmse:0.057583
## [18] train-rmse:0.055382 test-rmse:0.057319
## [19] train-rmse:0.055153 test-rmse:0.057216
## [20] train-rmse:0.054834 test-rmse:0.056980
## [21] train-rmse:0.053842 test-rmse:0.056111
## [22] train-rmse:0.053492 test-rmse:0.055759
## [23] train-rmse:0.053167 test-rmse:0.055535
## [24] train-rmse:0.052898 test-rmse:0.055295
## [25] train-rmse:0.052490 test-rmse:0.054877
## [26] train-rmse:0.052196 test-rmse:0.054712
## [27] train-rmse:0.052104 test-rmse:0.054709
## [28] train-rmse:0.051949 test-rmse:0.054637
## [29] train-rmse:0.051673 test-rmse:0.054327
## [30] train-rmse:0.051596 test-rmse:0.054263
## [31] train-rmse:0.051049 test-rmse:0.053888
## [32] train-rmse:0.050735 test-rmse:0.053596
## [33] train-rmse:0.050660 test-rmse:0.053569
## [34] train-rmse:0.050504 test-rmse:0.053527
## [35] train-rmse:0.050363 test-rmse:0.053510
## [36] train-rmse:0.050288 test-rmse:0.053497
## [37] train-rmse:0.049738 test-rmse:0.053048
## [38] train-rmse:0.049524 test-rmse:0.052847
## [39] train-rmse:0.049429 test-rmse:0.052796
## [40] train-rmse:0.049296 test-rmse:0.052838
## [41] train-rmse:0.049222 test-rmse:0.052882
## [42] train-rmse:0.049143 test-rmse:0.052875
## [43] train-rmse:0.048960 test-rmse:0.052961
## [44] train-rmse:0.048922 test-rmse:0.052955
```

```
## [45]  train-rmse:0.048862  test-rmse:0.052902
## [46]  train-rmse:0.048782  test-rmse:0.052833
## [47]  train-rmse:0.048646  test-rmse:0.052852
## [48]  train-rmse:0.048532  test-rmse:0.052814
## [49]  train-rmse:0.048500  test-rmse:0.052806
## [50]  train-rmse:0.048371  test-rmse:0.052755
## [51]  train-rmse:0.048156  test-rmse:0.052654
## [52]  train-rmse:0.048097  test-rmse:0.052605
## [53]  train-rmse:0.047988  test-rmse:0.052611
## [54]  train-rmse:0.047771  test-rmse:0.052593
## [55]  train-rmse:0.047612  test-rmse:0.052509
## [56]  train-rmse:0.047381  test-rmse:0.052259
## [57]  train-rmse:0.047132  test-rmse:0.051991
## [58]  train-rmse:0.047051  test-rmse:0.051985
## [59]  train-rmse:0.046560  test-rmse:0.051638
## [60]  train-rmse:0.046249  test-rmse:0.051351
## [61]  train-rmse:0.046043  test-rmse:0.051261
## [62]  train-rmse:0.045936  test-rmse:0.051303
## [63]  train-rmse:0.045078  test-rmse:0.050438
## [64]  train-rmse:0.044971  test-rmse:0.050383
## [65]  train-rmse:0.044873  test-rmse:0.050339
## [66]  train-rmse:0.044719  test-rmse:0.050227
## [67]  train-rmse:0.044627  test-rmse:0.050160
## [68]  train-rmse:0.044489  test-rmse:0.050118
## [69]  train-rmse:0.044373  test-rmse:0.050012
## [70]  train-rmse:0.044196  test-rmse:0.049967
## [71]  train-rmse:0.044167  test-rmse:0.049982
## [72]  train-rmse:0.044071  test-rmse:0.049953
## [73]  train-rmse:0.044038  test-rmse:0.049934
## [74]  train-rmse:0.043824  test-rmse:0.049720
## [75]  train-rmse:0.043768  test-rmse:0.049670
## [76]  train-rmse:0.043741  test-rmse:0.049693
## [77]  train-rmse:0.043539  test-rmse:0.049851
## [78]  train-rmse:0.043494  test-rmse:0.049897
## [79]  train-rmse:0.043315  test-rmse:0.049851
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## [98]  train-rmse:0.040713  test-rmse:0.048205
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## [711]      train-rmse:0.020239 test-rmse:0.044246
## [712]      train-rmse:0.020236 test-rmse:0.044246
## [713]      train-rmse:0.020223 test-rmse:0.044257
## [714]      train-rmse:0.020217 test-rmse:0.044261
## [715]      train-rmse:0.020215 test-rmse:0.044262
## [716]      train-rmse:0.020205 test-rmse:0.044266
## [717]      train-rmse:0.020184 test-rmse:0.044266
## [718]      train-rmse:0.020174 test-rmse:0.044269
## [719]      train-rmse:0.020164 test-rmse:0.044270
## [720]      train-rmse:0.020153 test-rmse:0.044271
## [721]      train-rmse:0.020137 test-rmse:0.044277
## [722]      train-rmse:0.020136 test-rmse:0.044279
## [723]      train-rmse:0.020130 test-rmse:0.044280
## [724]      train-rmse:0.020122 test-rmse:0.044283
## [725]      train-rmse:0.020114 test-rmse:0.044283
## [726]      train-rmse:0.020105 test-rmse:0.044287
## [727]      train-rmse:0.020095 test-rmse:0.044289
## [728]      train-rmse:0.020089 test-rmse:0.044304
## [729]      train-rmse:0.020087 test-rmse:0.044306
## [730]      train-rmse:0.020074 test-rmse:0.044315
## [731]      train-rmse:0.020061 test-rmse:0.044322
## [732]      train-rmse:0.020052 test-rmse:0.044318
## [733]      train-rmse:0.020017 test-rmse:0.044319
## [734]      train-rmse:0.020010 test-rmse:0.044312
## [735]      train-rmse:0.019986 test-rmse:0.044311
## [736]      train-rmse:0.019972 test-rmse:0.044302
## [737]      train-rmse:0.019959 test-rmse:0.044305
## [738]      train-rmse:0.019944 test-rmse:0.044307
## [739]      train-rmse:0.019925 test-rmse:0.044330
## [740]      train-rmse:0.019920 test-rmse:0.044331
## [741]      train-rmse:0.019905 test-rmse:0.044352
## [742]      train-rmse:0.019900 test-rmse:0.044351
## [743]      train-rmse:0.019884 test-rmse:0.044346
## [744]      train-rmse:0.019871 test-rmse:0.044341
## [745]      train-rmse:0.019854 test-rmse:0.044339
## [746]      train-rmse:0.019842 test-rmse:0.044350
```

```
## [747]      train-rmse:0.019838 test-rmse:0.044348
## [748]      train-rmse:0.019822 test-rmse:0.044349
## [749]      train-rmse:0.019803 test-rmse:0.044360
## [750]      train-rmse:0.019792 test-rmse:0.044367
## [751]      train-rmse:0.019758 test-rmse:0.044374
## [752]      train-rmse:0.019747 test-rmse:0.044372
## [753]      train-rmse:0.019740 test-rmse:0.044370
## [754]      train-rmse:0.019728 test-rmse:0.044370
## [755]      train-rmse:0.019712 test-rmse:0.044368
## [756]      train-rmse:0.019693 test-rmse:0.044368
## [757]      train-rmse:0.019682 test-rmse:0.044362
## [758]      train-rmse:0.019674 test-rmse:0.044363
## [759]      train-rmse:0.019664 test-rmse:0.044360
## [760]      train-rmse:0.019657 test-rmse:0.044353
## [761]      train-rmse:0.019638 test-rmse:0.044360
## [762]      train-rmse:0.019626 test-rmse:0.044356
## [763]      train-rmse:0.019606 test-rmse:0.044364
## [764]      train-rmse:0.019573 test-rmse:0.044336
## [765]      train-rmse:0.019556 test-rmse:0.044333
## [766]      train-rmse:0.019538 test-rmse:0.044327
## [767]      train-rmse:0.019516 test-rmse:0.044315
## [768]      train-rmse:0.019507 test-rmse:0.044313
## [769]      train-rmse:0.019493 test-rmse:0.044311
## [770]      train-rmse:0.019471 test-rmse:0.044313
## [771]      train-rmse:0.019458 test-rmse:0.044326
## [772]      train-rmse:0.019433 test-rmse:0.044320
## [773]      train-rmse:0.019430 test-rmse:0.044317
## [774]      train-rmse:0.019407 test-rmse:0.044303
## [775]      train-rmse:0.019397 test-rmse:0.044301
## [776]      train-rmse:0.019389 test-rmse:0.044301
## [777]      train-rmse:0.019376 test-rmse:0.044299
## [778]      train-rmse:0.019370 test-rmse:0.044300
## [779]      train-rmse:0.019354 test-rmse:0.044293
## [780]      train-rmse:0.019330 test-rmse:0.044281
## [781]      train-rmse:0.019319 test-rmse:0.044279
## [782]      train-rmse:0.019306 test-rmse:0.044274
## [783]      train-rmse:0.019289 test-rmse:0.044272
## [784]      train-rmse:0.019275 test-rmse:0.044268
## [785]      train-rmse:0.019248 test-rmse:0.044264
## [786]      train-rmse:0.019241 test-rmse:0.044269
## [787]      train-rmse:0.019214 test-rmse:0.044275
## [788]      train-rmse:0.019211 test-rmse:0.044275
## [789]      train-rmse:0.019196 test-rmse:0.044279
## [790]      train-rmse:0.019185 test-rmse:0.044275
## [791]      train-rmse:0.019163 test-rmse:0.044284
## [792]      train-rmse:0.019153 test-rmse:0.044289
## [793]      train-rmse:0.019150 test-rmse:0.044283
## [794]      train-rmse:0.019137 test-rmse:0.044279
## [795]      train-rmse:0.019132 test-rmse:0.044280
## [796]      train-rmse:0.019109 test-rmse:0.044275
## [797]      train-rmse:0.019097 test-rmse:0.044274
## [798]      train-rmse:0.019081 test-rmse:0.044275
## [799]      train-rmse:0.019076 test-rmse:0.044277
## [800]      train-rmse:0.019061 test-rmse:0.044267
```

```
## [801]     train-rmse:0.019035 test-rmse:0.044275
## [802]     train-rmse:0.019027 test-rmse:0.044272
## [803]     train-rmse:0.019021 test-rmse:0.044271
## [804]     train-rmse:0.019008 test-rmse:0.044288
## [805]     train-rmse:0.019000 test-rmse:0.044290
## [806]     train-rmse:0.018989 test-rmse:0.044289
## [807]     train-rmse:0.018972 test-rmse:0.044292
## [808]     train-rmse:0.018963 test-rmse:0.044292
## [809]     train-rmse:0.018962 test-rmse:0.044291
## [810]     train-rmse:0.018959 test-rmse:0.044290
## [811]     train-rmse:0.018947 test-rmse:0.044296
## [812]     train-rmse:0.018939 test-rmse:0.044299
## [813]     train-rmse:0.018921 test-rmse:0.044297
## [814]     train-rmse:0.018910 test-rmse:0.044293
## [815]     train-rmse:0.018898 test-rmse:0.044296
## [816]     train-rmse:0.018884 test-rmse:0.044296
## [817]     train-rmse:0.018870 test-rmse:0.044295
## [818]     train-rmse:0.018867 test-rmse:0.044298
## [819]     train-rmse:0.018863 test-rmse:0.044303
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## [822]     train-rmse:0.018844 test-rmse:0.044305
## [823]     train-rmse:0.018824 test-rmse:0.044294
## [824]     train-rmse:0.018811 test-rmse:0.044294
## [825]     train-rmse:0.018799 test-rmse:0.044298
## [826]     train-rmse:0.018778 test-rmse:0.044283
## [827]     train-rmse:0.018764 test-rmse:0.044282
## [828]     train-rmse:0.018744 test-rmse:0.044294
## [829]     train-rmse:0.018722 test-rmse:0.044276
## [830]     train-rmse:0.018711 test-rmse:0.044269
## [831]     train-rmse:0.018706 test-rmse:0.044265
## [832]     train-rmse:0.018704 test-rmse:0.044262
## [833]     train-rmse:0.018699 test-rmse:0.044261
## [834]     train-rmse:0.018692 test-rmse:0.044260
## [835]     train-rmse:0.018686 test-rmse:0.044263
## [836]     train-rmse:0.018672 test-rmse:0.044272
## [837]     train-rmse:0.018666 test-rmse:0.044273
## [838]     train-rmse:0.018651 test-rmse:0.044275
## [839]     train-rmse:0.018629 test-rmse:0.044280
## [840]     train-rmse:0.018619 test-rmse:0.044281
## [841]     train-rmse:0.018608 test-rmse:0.044278
## [842]     train-rmse:0.018595 test-rmse:0.044283
## [843]     train-rmse:0.018578 test-rmse:0.044291
## [844]     train-rmse:0.018572 test-rmse:0.044292
## [845]     train-rmse:0.018560 test-rmse:0.044301
## [846]     train-rmse:0.018541 test-rmse:0.044305
## [847]     train-rmse:0.018510 test-rmse:0.044307
## [848]     train-rmse:0.018496 test-rmse:0.044310
## [849]     train-rmse:0.018488 test-rmse:0.044311
## [850]     train-rmse:0.018478 test-rmse:0.044313
## [851]     train-rmse:0.018469 test-rmse:0.044323
## [852]     train-rmse:0.018460 test-rmse:0.044323
## [853]     train-rmse:0.018459 test-rmse:0.044323
## [854]     train-rmse:0.018454 test-rmse:0.044316
```

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## [855]     train-rmse:0.018442 test-rmse:0.044316
## [856]     train-rmse:0.018430 test-rmse:0.044315
## [857]     train-rmse:0.018418 test-rmse:0.044313
## [858]     train-rmse:0.018386 test-rmse:0.044316
## [859]     train-rmse:0.018375 test-rmse:0.044313
## [860]     train-rmse:0.018367 test-rmse:0.044314
## [861]     train-rmse:0.018355 test-rmse:0.044314
## [862]     train-rmse:0.018338 test-rmse:0.044312
## [863]     train-rmse:0.018329 test-rmse:0.044310
## [864]     train-rmse:0.018318 test-rmse:0.044310
## [865]     train-rmse:0.018312 test-rmse:0.044307
## [866]     train-rmse:0.018304 test-rmse:0.044313
## [867]     train-rmse:0.018303 test-rmse:0.044312
## [868]     train-rmse:0.018284 test-rmse:0.044304
## [869]     train-rmse:0.018278 test-rmse:0.044305
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## [874]     train-rmse:0.018171 test-rmse:0.044260
## [875]     train-rmse:0.018160 test-rmse:0.044262
## [876]     train-rmse:0.018137 test-rmse:0.044259
## [877]     train-rmse:0.018119 test-rmse:0.044249
## [878]     train-rmse:0.018115 test-rmse:0.044248
## [879]     train-rmse:0.018108 test-rmse:0.044249
## [880]     train-rmse:0.018102 test-rmse:0.044250
## [881]     train-rmse:0.018085 test-rmse:0.044238
## [882]     train-rmse:0.018078 test-rmse:0.044238
## [883]     train-rmse:0.018060 test-rmse:0.044263
## [884]     train-rmse:0.018049 test-rmse:0.044257
## [885]     train-rmse:0.018033 test-rmse:0.044263
## [886]     train-rmse:0.018015 test-rmse:0.044264
## [887]     train-rmse:0.018009 test-rmse:0.044261
## [888]     train-rmse:0.018005 test-rmse:0.044259
## [889]     train-rmse:0.018002 test-rmse:0.044262
## [890]     train-rmse:0.018000 test-rmse:0.044265
## [891]     train-rmse:0.017988 test-rmse:0.044253
## [892]     train-rmse:0.017977 test-rmse:0.044251
## [893]     train-rmse:0.017945 test-rmse:0.044255
## [894]     train-rmse:0.017934 test-rmse:0.044249
## [895]     train-rmse:0.017929 test-rmse:0.044249
## [896]     train-rmse:0.017917 test-rmse:0.044247
## [897]     train-rmse:0.017878 test-rmse:0.044226
## [898]     train-rmse:0.017866 test-rmse:0.044229
## [899]     train-rmse:0.017855 test-rmse:0.044231
## [900]     train-rmse:0.017853 test-rmse:0.044232
## [901]     train-rmse:0.017843 test-rmse:0.044220
## [902]     train-rmse:0.017821 test-rmse:0.044216
## [903]     train-rmse:0.017814 test-rmse:0.044215
## [904]     train-rmse:0.017790 test-rmse:0.044207
## [905]     train-rmse:0.017777 test-rmse:0.044213
## [906]     train-rmse:0.017776 test-rmse:0.044212
## [907]     train-rmse:0.017766 test-rmse:0.044212
## [908]     train-rmse:0.017763 test-rmse:0.044214
```

```
## [909]     train-rmse:0.017748 test-rmse:0.044214
## [910]     train-rmse:0.017736 test-rmse:0.044217
## [911]     train-rmse:0.017706 test-rmse:0.044196
## [912]     train-rmse:0.017695 test-rmse:0.044203
## [913]     train-rmse:0.017688 test-rmse:0.044200
## [914]     train-rmse:0.017683 test-rmse:0.044200
## [915]     train-rmse:0.017680 test-rmse:0.044202
## [916]     train-rmse:0.017670 test-rmse:0.044201
## [917]     train-rmse:0.017658 test-rmse:0.044204
## [918]     train-rmse:0.017656 test-rmse:0.044203
## [919]     train-rmse:0.017649 test-rmse:0.044208
## [920]     train-rmse:0.017642 test-rmse:0.044208
## [921]     train-rmse:0.017634 test-rmse:0.044211
## [922]     train-rmse:0.017629 test-rmse:0.044212
## [923]     train-rmse:0.017618 test-rmse:0.044211
## [924]     train-rmse:0.017603 test-rmse:0.044212
## [925]     train-rmse:0.017592 test-rmse:0.044207
## [926]     train-rmse:0.017586 test-rmse:0.044206
## [927]     train-rmse:0.017583 test-rmse:0.044206
## [928]     train-rmse:0.017580 test-rmse:0.044209
## [929]     train-rmse:0.017572 test-rmse:0.044207
## [930]     train-rmse:0.017553 test-rmse:0.044217
## [931]     train-rmse:0.017548 test-rmse:0.044214
## [932]     train-rmse:0.017546 test-rmse:0.044213
## [933]     train-rmse:0.017537 test-rmse:0.044216
## [934]     train-rmse:0.017528 test-rmse:0.044215
## [935]     train-rmse:0.017524 test-rmse:0.044220
## [936]     train-rmse:0.017517 test-rmse:0.044219
## [937]     train-rmse:0.017510 test-rmse:0.044224
## [938]     train-rmse:0.017509 test-rmse:0.044224
## [939]     train-rmse:0.017506 test-rmse:0.044225
## [940]     train-rmse:0.017498 test-rmse:0.044227
## [941]     train-rmse:0.017481 test-rmse:0.044230
## [942]     train-rmse:0.017472 test-rmse:0.044229
## [943]     train-rmse:0.017456 test-rmse:0.044234
## [944]     train-rmse:0.017443 test-rmse:0.044234
## [945]     train-rmse:0.017421 test-rmse:0.044229
## [946]     train-rmse:0.017414 test-rmse:0.044227
## [947]     train-rmse:0.017399 test-rmse:0.044228
## [948]     train-rmse:0.017394 test-rmse:0.044227
## [949]     train-rmse:0.017391 test-rmse:0.044225
## [950]     train-rmse:0.017383 test-rmse:0.044224
## [951]     train-rmse:0.017378 test-rmse:0.044223
## [952]     train-rmse:0.017374 test-rmse:0.044222
## [953]     train-rmse:0.017369 test-rmse:0.044221
## [954]     train-rmse:0.017352 test-rmse:0.044227
## [955]     train-rmse:0.017351 test-rmse:0.044226
## [956]     train-rmse:0.017348 test-rmse:0.044234
## [957]     train-rmse:0.017345 test-rmse:0.044234
## [958]     train-rmse:0.017337 test-rmse:0.044233
## [959]     train-rmse:0.017321 test-rmse:0.044226
## [960]     train-rmse:0.017292 test-rmse:0.044215
## [961]     train-rmse:0.017285 test-rmse:0.044221
## [962]     train-rmse:0.017273 test-rmse:0.044217
```

```
## [963]      train-rmse:0.017256 test-rmse:0.044218
## [964]      train-rmse:0.017241 test-rmse:0.044225
## [965]      train-rmse:0.017237 test-rmse:0.044225
## [966]      train-rmse:0.017230 test-rmse:0.044225
## [967]      train-rmse:0.017213 test-rmse:0.044233
## [968]      train-rmse:0.017200 test-rmse:0.044238
## [969]      train-rmse:0.017187 test-rmse:0.044231
## [970]      train-rmse:0.017175 test-rmse:0.044233
## [971]      train-rmse:0.017170 test-rmse:0.044232
## [972]      train-rmse:0.017161 test-rmse:0.044232
## [973]      train-rmse:0.017145 test-rmse:0.044228
## [974]      train-rmse:0.017136 test-rmse:0.044230
## [975]      train-rmse:0.017116 test-rmse:0.044228
## [976]      train-rmse:0.017110 test-rmse:0.044230
## [977]      train-rmse:0.017090 test-rmse:0.044211
## [978]      train-rmse:0.017088 test-rmse:0.044213
## [979]      train-rmse:0.017079 test-rmse:0.044210
## [980]      train-rmse:0.017061 test-rmse:0.044215
## [981]      train-rmse:0.017056 test-rmse:0.044213
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## [983]      train-rmse:0.017052 test-rmse:0.044214
## [984]      train-rmse:0.017051 test-rmse:0.044214
## [985]      train-rmse:0.017049 test-rmse:0.044214
## [986]      train-rmse:0.017044 test-rmse:0.044213
## [987]      train-rmse:0.017039 test-rmse:0.044214
## [988]      train-rmse:0.017034 test-rmse:0.044212
## [989]      train-rmse:0.017027 test-rmse:0.044213
## [990]      train-rmse:0.017022 test-rmse:0.044211
## [991]      train-rmse:0.017009 test-rmse:0.044206
## [992]      train-rmse:0.016999 test-rmse:0.044206
## [993]      train-rmse:0.016994 test-rmse:0.044204
## [994]      train-rmse:0.016989 test-rmse:0.044203
## [995]      train-rmse:0.016983 test-rmse:0.044204
## [996]      train-rmse:0.016965 test-rmse:0.044209
## [997]      train-rmse:0.016948 test-rmse:0.044216
## [998]      train-rmse:0.016942 test-rmse:0.044222
## [999]      train-rmse:0.016939 test-rmse:0.044222
## [1000]     train-rmse:0.016936 test-rmse:0.044220
```

```r
kick_model_xgboost = xgboost(data = kick_xgb_train, max.depth = 3, nrounds = 518, verbose = 0)
summary(kick_model_xgboost)
```

```
##                 Length Class               Mode
## handle               1 xgb.Booster.handle externalptr
## raw             602613 -none-              raw
## niter                1 -none-              numeric
## evaluation_log       2 data.table          list
## call                14 -none-              call
## params               2 -none-              list
## callbacks            1 -none-              list
## feature_names       16 -none-              character
## nfeatures            1 -none-              numeric
```
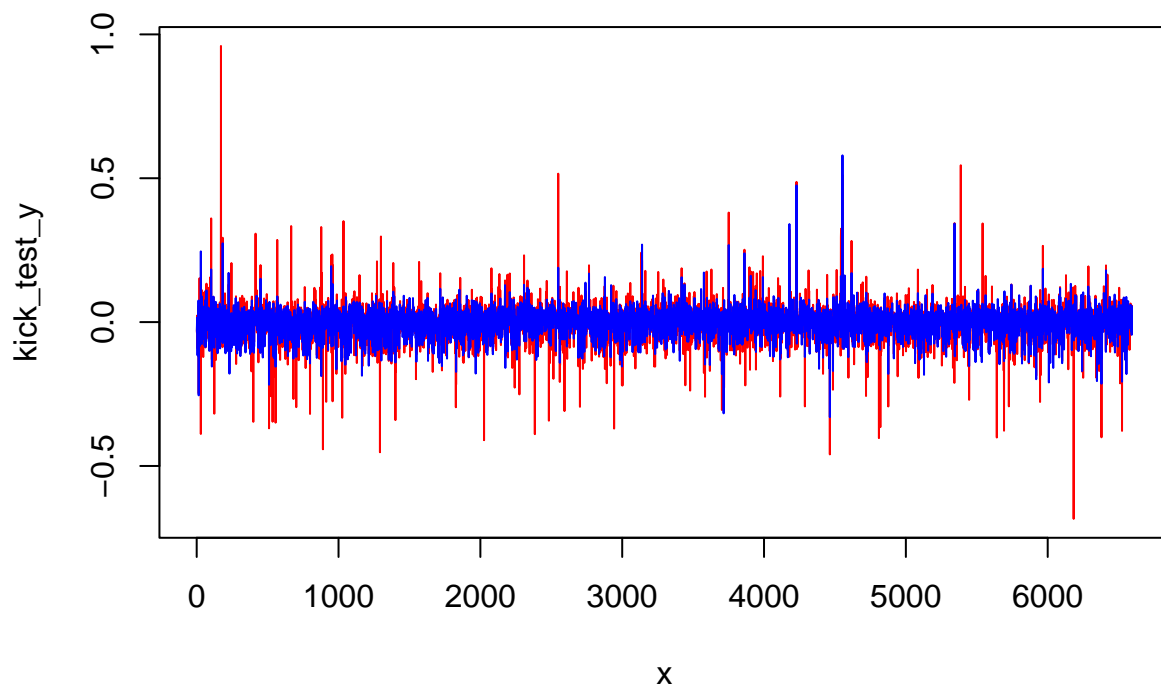
```
kick_pred_y = predict(kick_model_xgboost, kick_xgb_test)
mean((kick_test_y - kick_pred_y)^2)
```

```
## [1] 0.001953909
```

```
RMSE(kick_test_y, kick_pred_y)
```

```
## [1] 0.04420304
```

```
y_kick_test_mean = mean(kick_test_y)
x = 1:length(kick_test_y)
plot(x, kick_test_y, col = "red", type = "l")
lines(x, kick_pred_y, col = "blue", type = "l")
```



```
set.seed(12321)
sample <- sample(c(TRUE, FALSE), nrow(go_data), replace = TRUE, prob = c(0.7, 0.3))
go_data_train <- go_data[sample, ]
go_data_test <- go_data[!sample, ]
go_train_x <- data.matrix(go_data_train[, -1])
go_train_y <- go_data_train$wpa
go_test_x <- data.matrix(go_data_test[, -1])
go_test_y <- go_data_test$wpa
go_xgb_train = xgb.DMatrix(data = go_train_x, label = go_train_y)
```

```
go_xgb_test = xgb.DMatrix(data = go_test_x, label = go_test_y)
go_watchlist = list(train=go_xgb_train, test=go_xgb_test)
go_model = xgb.train(data = go_xgb_train, max.depth = 3, watchlist=go_watchlist, nrounds = 1000)
```

```
## [1]   train-rmse:0.357712 test-rmse:0.360487
## [2]   train-rmse:0.257851 test-rmse:0.260568
## [3]   train-rmse:0.190442 test-rmse:0.193010
## [4]   train-rmse:0.145550 test-rmse:0.147799
## [5]   train-rmse:0.117584 test-rmse:0.119746
## [6]   train-rmse:0.097521 test-rmse:0.099158
## [7]   train-rmse:0.087496 test-rmse:0.089351
## [8]   train-rmse:0.080703 test-rmse:0.082362
## [9]   train-rmse:0.076726 test-rmse:0.078378
## [10] train-rmse:0.074934 test-rmse:0.076703
## [11] train-rmse:0.074036 test-rmse:0.075808
## [12] train-rmse:0.073120 test-rmse:0.074900
## [13] train-rmse:0.070517 test-rmse:0.072179
## [14] train-rmse:0.069573 test-rmse:0.071416
## [15] train-rmse:0.069235 test-rmse:0.071250
## [16] train-rmse:0.067463 test-rmse:0.069621
## [17] train-rmse:0.066761 test-rmse:0.069212
## [18] train-rmse:0.065654 test-rmse:0.068402
## [19] train-rmse:0.065168 test-rmse:0.067845
## [20] train-rmse:0.064383 test-rmse:0.067215
## [21] train-rmse:0.063858 test-rmse:0.066701
## [22] train-rmse:0.063158 test-rmse:0.066001
## [23] train-rmse:0.062962 test-rmse:0.066081
## [24] train-rmse:0.062557 test-rmse:0.065939
## [25] train-rmse:0.062207 test-rmse:0.065982
## [26] train-rmse:0.062001 test-rmse:0.066022
## [27] train-rmse:0.061187 test-rmse:0.065191
## [28] train-rmse:0.060995 test-rmse:0.064993
## [29] train-rmse:0.060815 test-rmse:0.065013
## [30] train-rmse:0.060720 test-rmse:0.065039
## [31] train-rmse:0.060345 test-rmse:0.064733
## [32] train-rmse:0.059763 test-rmse:0.064352
## [33] train-rmse:0.059464 test-rmse:0.064294
## [34] train-rmse:0.059244 test-rmse:0.064106
## [35] train-rmse:0.058997 test-rmse:0.064241
## [36] train-rmse:0.058921 test-rmse:0.064227
## [37] train-rmse:0.058658 test-rmse:0.064062
## [38] train-rmse:0.058331 test-rmse:0.063931
## [39] train-rmse:0.058205 test-rmse:0.063886
## [40] train-rmse:0.058054 test-rmse:0.063899
## [41] train-rmse:0.057865 test-rmse:0.064112
## [42] train-rmse:0.057537 test-rmse:0.063988
## [43] train-rmse:0.057272 test-rmse:0.064007
## [44] train-rmse:0.057220 test-rmse:0.064056
## [45] train-rmse:0.056976 test-rmse:0.064117
## [46] train-rmse:0.056759 test-rmse:0.063983
## [47] train-rmse:0.056369 test-rmse:0.063709
## [48] train-rmse:0.056086 test-rmse:0.063483
## [49] train-rmse:0.055885 test-rmse:0.063328
```

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## [50] train-rmse:0.055780 test-rmse:0.063215
## [51] train-rmse:0.055609 test-rmse:0.063210
## [52] train-rmse:0.055561 test-rmse:0.063237
## [53] train-rmse:0.055457 test-rmse:0.063226
## [54] train-rmse:0.055372 test-rmse:0.063083
## [55] train-rmse:0.055008 test-rmse:0.062851
## [56] train-rmse:0.054888 test-rmse:0.062796
## [57] train-rmse:0.054831 test-rmse:0.062766
## [58] train-rmse:0.054743 test-rmse:0.062750
## [59] train-rmse:0.054584 test-rmse:0.062683
## [60] train-rmse:0.054477 test-rmse:0.062696
## [61] train-rmse:0.054044 test-rmse:0.062603
## [62] train-rmse:0.053769 test-rmse:0.062357
## [63] train-rmse:0.053562 test-rmse:0.062367
## [64] train-rmse:0.053168 test-rmse:0.062047
## [65] train-rmse:0.053023 test-rmse:0.061960
## [66] train-rmse:0.052823 test-rmse:0.061806
## [67] train-rmse:0.052747 test-rmse:0.061760
## [68] train-rmse:0.052710 test-rmse:0.061757
## [69] train-rmse:0.052576 test-rmse:0.061754
## [70] train-rmse:0.052484 test-rmse:0.061771
## [71] train-rmse:0.052409 test-rmse:0.061763
## [72] train-rmse:0.052360 test-rmse:0.061762
## [73] train-rmse:0.052323 test-rmse:0.061745
## [74] train-rmse:0.052009 test-rmse:0.061440
## [75] train-rmse:0.051817 test-rmse:0.061371
## [76] train-rmse:0.051434 test-rmse:0.061060
## [77] train-rmse:0.051219 test-rmse:0.060813
## [78] train-rmse:0.051042 test-rmse:0.060649
## [79] train-rmse:0.050888 test-rmse:0.060620
## [80] train-rmse:0.050833 test-rmse:0.060560
## [81] train-rmse:0.050699 test-rmse:0.060566
## [82] train-rmse:0.050612 test-rmse:0.060521
## [83] train-rmse:0.050573 test-rmse:0.060536
## [84] train-rmse:0.050493 test-rmse:0.060585
## [85] train-rmse:0.050458 test-rmse:0.060573
## [86] train-rmse:0.050338 test-rmse:0.060593
## [87] train-rmse:0.050211 test-rmse:0.060611
## [88] train-rmse:0.050078 test-rmse:0.060728
## [89] train-rmse:0.050059 test-rmse:0.060734
## [90] train-rmse:0.050041 test-rmse:0.060724
## [91] train-rmse:0.049982 test-rmse:0.060725
## [92] train-rmse:0.049792 test-rmse:0.060684
## [93] train-rmse:0.049701 test-rmse:0.060676
## [94] train-rmse:0.049608 test-rmse:0.060657
## [95] train-rmse:0.049522 test-rmse:0.060664
## [96] train-rmse:0.049497 test-rmse:0.060654
## [97] train-rmse:0.049424 test-rmse:0.060654
## [98] train-rmse:0.049358 test-rmse:0.060679
## [99] train-rmse:0.049296 test-rmse:0.060659
## [100]     train-rmse:0.049205 test-rmse:0.060666
## [101]     train-rmse:0.049142 test-rmse:0.060617
## [102]     train-rmse:0.049119 test-rmse:0.060625
## [103]     train-rmse:0.049078 test-rmse:0.060629
```

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## [104]     train-rmse:0.048996 test-rmse:0.060649
## [105]     train-rmse:0.048932 test-rmse:0.060658
## [106]     train-rmse:0.048822 test-rmse:0.060565
## [107]     train-rmse:0.048678 test-rmse:0.060539
## [108]     train-rmse:0.048659 test-rmse:0.060536
## [109]     train-rmse:0.048568 test-rmse:0.060567
## [110]     train-rmse:0.048524 test-rmse:0.060623
## [111]     train-rmse:0.048321 test-rmse:0.060542
## [112]     train-rmse:0.048193 test-rmse:0.060496
## [113]     train-rmse:0.048131 test-rmse:0.060468
## [114]     train-rmse:0.048097 test-rmse:0.060466
## [115]     train-rmse:0.048015 test-rmse:0.060381
## [116]     train-rmse:0.047872 test-rmse:0.060373
## [117]     train-rmse:0.047812 test-rmse:0.060334
## [118]     train-rmse:0.047746 test-rmse:0.060350
## [119]     train-rmse:0.047598 test-rmse:0.060334
## [120]     train-rmse:0.047460 test-rmse:0.060281
## [121]     train-rmse:0.047405 test-rmse:0.060276
## [122]     train-rmse:0.047320 test-rmse:0.060298
## [123]     train-rmse:0.047232 test-rmse:0.060279
## [124]     train-rmse:0.047168 test-rmse:0.060283
## [125]     train-rmse:0.047132 test-rmse:0.060282
## [126]     train-rmse:0.046993 test-rmse:0.060354
## [127]     train-rmse:0.046930 test-rmse:0.060320
## [128]     train-rmse:0.046807 test-rmse:0.060377
## [129]     train-rmse:0.046709 test-rmse:0.060299
## [130]     train-rmse:0.046627 test-rmse:0.060313
## [131]     train-rmse:0.046542 test-rmse:0.060335
## [132]     train-rmse:0.046508 test-rmse:0.060328
## [133]     train-rmse:0.046403 test-rmse:0.060398
## [134]     train-rmse:0.046320 test-rmse:0.060375
## [135]     train-rmse:0.046219 test-rmse:0.060403
## [136]     train-rmse:0.046201 test-rmse:0.060394
## [137]     train-rmse:0.046113 test-rmse:0.060434
## [138]     train-rmse:0.046054 test-rmse:0.060414
## [139]     train-rmse:0.046026 test-rmse:0.060436
## [140]     train-rmse:0.045988 test-rmse:0.060452
## [141]     train-rmse:0.045881 test-rmse:0.060360
## [142]     train-rmse:0.045723 test-rmse:0.060330
## [143]     train-rmse:0.045650 test-rmse:0.060328
## [144]     train-rmse:0.045538 test-rmse:0.060345
## [145]     train-rmse:0.045504 test-rmse:0.060342
## [146]     train-rmse:0.045472 test-rmse:0.060332
## [147]     train-rmse:0.045442 test-rmse:0.060320
## [148]     train-rmse:0.045378 test-rmse:0.060318
## [149]     train-rmse:0.045213 test-rmse:0.060293
## [150]     train-rmse:0.045069 test-rmse:0.060213
## [151]     train-rmse:0.044965 test-rmse:0.060223
## [152]     train-rmse:0.044932 test-rmse:0.060226
## [153]     train-rmse:0.044840 test-rmse:0.060292
## [154]     train-rmse:0.044708 test-rmse:0.060301
## [155]     train-rmse:0.044661 test-rmse:0.060261
## [156]     train-rmse:0.044618 test-rmse:0.060256
## [157]     train-rmse:0.044415 test-rmse:0.060263
```

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## [158]      train-rmse:0.044370 test-rmse:0.060253
## [159]      train-rmse:0.044348 test-rmse:0.060269
## [160]      train-rmse:0.044163 test-rmse:0.060142
## [161]      train-rmse:0.044116 test-rmse:0.060156
## [162]      train-rmse:0.044109 test-rmse:0.060161
## [163]      train-rmse:0.044094 test-rmse:0.060206
## [164]      train-rmse:0.044016 test-rmse:0.060193
## [165]      train-rmse:0.043953 test-rmse:0.060198
## [166]      train-rmse:0.043819 test-rmse:0.060138
## [167]      train-rmse:0.043786 test-rmse:0.060128
## [168]      train-rmse:0.043760 test-rmse:0.060115
## [169]      train-rmse:0.043697 test-rmse:0.060073
## [170]      train-rmse:0.043643 test-rmse:0.060067
## [171]      train-rmse:0.043522 test-rmse:0.060050
## [172]      train-rmse:0.043379 test-rmse:0.059916
## [173]      train-rmse:0.043317 test-rmse:0.059958
## [174]      train-rmse:0.043241 test-rmse:0.059946
## [175]      train-rmse:0.043212 test-rmse:0.059933
## [176]      train-rmse:0.043118 test-rmse:0.059913
## [177]      train-rmse:0.043055 test-rmse:0.059897
## [178]      train-rmse:0.043004 test-rmse:0.059896
## [179]      train-rmse:0.042985 test-rmse:0.059878
## [180]      train-rmse:0.042976 test-rmse:0.059884
## [181]      train-rmse:0.042962 test-rmse:0.059893
## [182]      train-rmse:0.042948 test-rmse:0.059882
## [183]      train-rmse:0.042936 test-rmse:0.059876
## [184]      train-rmse:0.042900 test-rmse:0.059887
## [185]      train-rmse:0.042843 test-rmse:0.059907
## [186]      train-rmse:0.042751 test-rmse:0.059897
## [187]      train-rmse:0.042698 test-rmse:0.059910
## [188]      train-rmse:0.042681 test-rmse:0.059911
## [189]      train-rmse:0.042608 test-rmse:0.059986
## [190]      train-rmse:0.042565 test-rmse:0.060007
## [191]      train-rmse:0.042456 test-rmse:0.060054
## [192]      train-rmse:0.042365 test-rmse:0.059911
## [193]      train-rmse:0.042326 test-rmse:0.059895
## [194]      train-rmse:0.042271 test-rmse:0.059880
## [195]      train-rmse:0.042238 test-rmse:0.059856
## [196]      train-rmse:0.042146 test-rmse:0.059836
## [197]      train-rmse:0.042081 test-rmse:0.059851
## [198]      train-rmse:0.042033 test-rmse:0.059845
## [199]      train-rmse:0.041994 test-rmse:0.059846
## [200]      train-rmse:0.041971 test-rmse:0.059849
## [201]      train-rmse:0.041906 test-rmse:0.059837
## [202]      train-rmse:0.041768 test-rmse:0.059864
## [203]      train-rmse:0.041732 test-rmse:0.059864
## [204]      train-rmse:0.041693 test-rmse:0.059863
## [205]      train-rmse:0.041663 test-rmse:0.059895
## [206]      train-rmse:0.041569 test-rmse:0.059931
## [207]      train-rmse:0.041514 test-rmse:0.059947
## [208]      train-rmse:0.041461 test-rmse:0.059942
## [209]      train-rmse:0.041372 test-rmse:0.059950
## [210]      train-rmse:0.041321 test-rmse:0.059956
## [211]      train-rmse:0.041296 test-rmse:0.059953
```

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## [212]     train-rmse:0.041283 test-rmse:0.059967
## [213]     train-rmse:0.041253 test-rmse:0.059973
## [214]     train-rmse:0.041241 test-rmse:0.059976
## [215]     train-rmse:0.041234 test-rmse:0.059979
## [216]     train-rmse:0.041176 test-rmse:0.059995
## [217]     train-rmse:0.041127 test-rmse:0.059982
## [218]     train-rmse:0.041048 test-rmse:0.060035
## [219]     train-rmse:0.041001 test-rmse:0.060088
## [220]     train-rmse:0.040982 test-rmse:0.060082
## [221]     train-rmse:0.040931 test-rmse:0.060091
## [222]     train-rmse:0.040896 test-rmse:0.060097
## [223]     train-rmse:0.040823 test-rmse:0.060119
## [224]     train-rmse:0.040782 test-rmse:0.060094
## [225]     train-rmse:0.040769 test-rmse:0.060085
## [226]     train-rmse:0.040684 test-rmse:0.060076
## [227]     train-rmse:0.040562 test-rmse:0.060176
## [228]     train-rmse:0.040544 test-rmse:0.060182
## [229]     train-rmse:0.040471 test-rmse:0.060181
## [230]     train-rmse:0.040463 test-rmse:0.060192
## [231]     train-rmse:0.040306 test-rmse:0.060006
## [232]     train-rmse:0.040253 test-rmse:0.060028
## [233]     train-rmse:0.040244 test-rmse:0.060055
## [234]     train-rmse:0.040227 test-rmse:0.060048
## [235]     train-rmse:0.040215 test-rmse:0.060050
## [236]     train-rmse:0.040189 test-rmse:0.060053
## [237]     train-rmse:0.040127 test-rmse:0.060058
## [238]     train-rmse:0.040104 test-rmse:0.060061
## [239]     train-rmse:0.040088 test-rmse:0.060062
## [240]     train-rmse:0.040004 test-rmse:0.060033
## [241]     train-rmse:0.039983 test-rmse:0.060067
## [242]     train-rmse:0.039914 test-rmse:0.060119
## [243]     train-rmse:0.039855 test-rmse:0.060114
## [244]     train-rmse:0.039821 test-rmse:0.060155
## [245]     train-rmse:0.039775 test-rmse:0.060214
## [246]     train-rmse:0.039715 test-rmse:0.060220
## [247]     train-rmse:0.039641 test-rmse:0.060233
## [248]     train-rmse:0.039613 test-rmse:0.060255
## [249]     train-rmse:0.039562 test-rmse:0.060270
## [250]     train-rmse:0.039491 test-rmse:0.060316
## [251]     train-rmse:0.039433 test-rmse:0.060310
## [252]     train-rmse:0.039417 test-rmse:0.060302
## [253]     train-rmse:0.039372 test-rmse:0.060263
## [254]     train-rmse:0.039341 test-rmse:0.060241
## [255]     train-rmse:0.039329 test-rmse:0.060230
## [256]     train-rmse:0.039275 test-rmse:0.060235
## [257]     train-rmse:0.039248 test-rmse:0.060268
## [258]     train-rmse:0.039216 test-rmse:0.060278
## [259]     train-rmse:0.039165 test-rmse:0.060257
## [260]     train-rmse:0.039135 test-rmse:0.060258
## [261]     train-rmse:0.039073 test-rmse:0.060267
## [262]     train-rmse:0.039043 test-rmse:0.060274
## [263]     train-rmse:0.038998 test-rmse:0.060289
## [264]     train-rmse:0.038897 test-rmse:0.060306
## [265]     train-rmse:0.038869 test-rmse:0.060311
```

```
## [266]     train-rmse:0.038836 test-rmse:0.060308
## [267]     train-rmse:0.038800 test-rmse:0.060299
## [268]     train-rmse:0.038640 test-rmse:0.060224
## [269]     train-rmse:0.038618 test-rmse:0.060220
## [270]     train-rmse:0.038557 test-rmse:0.060220
## [271]     train-rmse:0.038512 test-rmse:0.060267
## [272]     train-rmse:0.038479 test-rmse:0.060261
## [273]     train-rmse:0.038469 test-rmse:0.060264
## [274]     train-rmse:0.038445 test-rmse:0.060269
## [275]     train-rmse:0.038395 test-rmse:0.060238
## [276]     train-rmse:0.038324 test-rmse:0.060222
## [277]     train-rmse:0.038288 test-rmse:0.060227
## [278]     train-rmse:0.038217 test-rmse:0.060214
## [279]     train-rmse:0.038011 test-rmse:0.060229
## [280]     train-rmse:0.037967 test-rmse:0.060240
## [281]     train-rmse:0.037938 test-rmse:0.060269
## [282]     train-rmse:0.037827 test-rmse:0.060262
## [283]     train-rmse:0.037759 test-rmse:0.060254
## [284]     train-rmse:0.037700 test-rmse:0.060272
## [285]     train-rmse:0.037667 test-rmse:0.060283
## [286]     train-rmse:0.037602 test-rmse:0.060269
## [287]     train-rmse:0.037436 test-rmse:0.060192
## [288]     train-rmse:0.037405 test-rmse:0.060160
## [289]     train-rmse:0.037356 test-rmse:0.060167
## [290]     train-rmse:0.037279 test-rmse:0.060123
## [291]     train-rmse:0.037260 test-rmse:0.060126
## [292]     train-rmse:0.037214 test-rmse:0.060115
## [293]     train-rmse:0.037190 test-rmse:0.060102
## [294]     train-rmse:0.037132 test-rmse:0.060117
## [295]     train-rmse:0.037051 test-rmse:0.060155
## [296]     train-rmse:0.037011 test-rmse:0.060146
## [297]     train-rmse:0.036967 test-rmse:0.060156
## [298]     train-rmse:0.036898 test-rmse:0.060122
## [299]     train-rmse:0.036834 test-rmse:0.060102
## [300]     train-rmse:0.036705 test-rmse:0.060039
## [301]     train-rmse:0.036651 test-rmse:0.060044
## [302]     train-rmse:0.036623 test-rmse:0.060059
## [303]     train-rmse:0.036593 test-rmse:0.060060
## [304]     train-rmse:0.036585 test-rmse:0.060054
## [305]     train-rmse:0.036575 test-rmse:0.060050
## [306]     train-rmse:0.036564 test-rmse:0.060044
## [307]     train-rmse:0.036546 test-rmse:0.060044
## [308]     train-rmse:0.036454 test-rmse:0.060053
## [309]     train-rmse:0.036397 test-rmse:0.060055
## [310]     train-rmse:0.036362 test-rmse:0.060054
## [311]     train-rmse:0.036350 test-rmse:0.060061
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## [314]     train-rmse:0.036185 test-rmse:0.060032
## [315]     train-rmse:0.036154 test-rmse:0.060003
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## [317]     train-rmse:0.036115 test-rmse:0.060022
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## [439]     train-rmse:0.031494 test-rmse:0.060521
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## [441]     train-rmse:0.031451 test-rmse:0.060517
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## [493]     train-rmse:0.029902 test-rmse:0.060590
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## [930]     train-rmse:0.020656 test-rmse:0.061459
## [931]     train-rmse:0.020641 test-rmse:0.061459
## [932]     train-rmse:0.020621 test-rmse:0.061457
## [933]     train-rmse:0.020618 test-rmse:0.061458
## [934]     train-rmse:0.020614 test-rmse:0.061457
## [935]     train-rmse:0.020606 test-rmse:0.061454
## [936]     train-rmse:0.020598 test-rmse:0.061452
## [937]     train-rmse:0.020594 test-rmse:0.061449
## [938]     train-rmse:0.020582 test-rmse:0.061444
## [939]     train-rmse:0.020561 test-rmse:0.061453
## [940]     train-rmse:0.020549 test-rmse:0.061443
## [941]     train-rmse:0.020504 test-rmse:0.061426
## [942]     train-rmse:0.020497 test-rmse:0.061439
## [943]     train-rmse:0.020481 test-rmse:0.061433
## [944]     train-rmse:0.020479 test-rmse:0.061439
## [945]     train-rmse:0.020466 test-rmse:0.061431
## [946]     train-rmse:0.020441 test-rmse:0.061462
## [947]     train-rmse:0.020435 test-rmse:0.061462
## [948]     train-rmse:0.020433 test-rmse:0.061463
## [949]     train-rmse:0.020426 test-rmse:0.061466
## [950]     train-rmse:0.020421 test-rmse:0.061467
## [951]     train-rmse:0.020418 test-rmse:0.061468
## [952]     train-rmse:0.020408 test-rmse:0.061472
## [953]     train-rmse:0.020361 test-rmse:0.061455
## [954]     train-rmse:0.020349 test-rmse:0.061454
## [955]     train-rmse:0.020337 test-rmse:0.061466
## [956]     train-rmse:0.020324 test-rmse:0.061472
## [957]     train-rmse:0.020293 test-rmse:0.061471
## [958]     train-rmse:0.020282 test-rmse:0.061468
## [959]     train-rmse:0.020263 test-rmse:0.061475
## [960]     train-rmse:0.020252 test-rmse:0.061477
## [961]     train-rmse:0.020226 test-rmse:0.061481
## [962]     train-rmse:0.020212 test-rmse:0.061483
## [963]     train-rmse:0.020199 test-rmse:0.061483
## [964]     train-rmse:0.020192 test-rmse:0.061480
## [965]     train-rmse:0.020162 test-rmse:0.061478
## [966]     train-rmse:0.020133 test-rmse:0.061478
## [967]     train-rmse:0.020116 test-rmse:0.061473
```

```
## [968]      train-rmse:0.020068 test-rmse:0.061474
## [969]      train-rmse:0.020059 test-rmse:0.061478
## [970]      train-rmse:0.020040 test-rmse:0.061474
## [971]      train-rmse:0.020022 test-rmse:0.061479
## [972]      train-rmse:0.019998 test-rmse:0.061491
## [973]      train-rmse:0.019970 test-rmse:0.061508
## [974]      train-rmse:0.019948 test-rmse:0.061510
## [975]      train-rmse:0.019927 test-rmse:0.061511
## [976]      train-rmse:0.019913 test-rmse:0.061512
## [977]      train-rmse:0.019900 test-rmse:0.061514
## [978]      train-rmse:0.019889 test-rmse:0.061511
## [979]      train-rmse:0.019884 test-rmse:0.061507
## [980]      train-rmse:0.019870 test-rmse:0.061517
## [981]      train-rmse:0.019843 test-rmse:0.061532
## [982]      train-rmse:0.019840 test-rmse:0.061532
## [983]      train-rmse:0.019821 test-rmse:0.061521
## [984]      train-rmse:0.019807 test-rmse:0.061517
## [985]      train-rmse:0.019798 test-rmse:0.061518
## [986]      train-rmse:0.019767 test-rmse:0.061514
## [987]      train-rmse:0.019756 test-rmse:0.061518
## [988]      train-rmse:0.019742 test-rmse:0.061520
## [989]      train-rmse:0.019721 test-rmse:0.061544
## [990]      train-rmse:0.019694 test-rmse:0.061552
## [991]      train-rmse:0.019667 test-rmse:0.061556
## [992]      train-rmse:0.019661 test-rmse:0.061556
## [993]      train-rmse:0.019650 test-rmse:0.061567
## [994]      train-rmse:0.019628 test-rmse:0.061576
## [995]      train-rmse:0.019617 test-rmse:0.061572
## [996]      train-rmse:0.019607 test-rmse:0.061572
## [997]      train-rmse:0.019599 test-rmse:0.061566
## [998]      train-rmse:0.019591 test-rmse:0.061565
## [999]      train-rmse:0.019570 test-rmse:0.061559
## [1000]     train-rmse:0.019555 test-rmse:0.061560
```

```
go_model_xgboost = xgboost(data = go_xgb_train, max.depth = 3, nrounds = 183, verbose = 0)
summary(go_model_xgboost)
```

```
##                  Length Class              Mode
## handle                1 xgb.Booster.handle externalptr
## raw              214453 -none-             raw
## niter                 1 -none-             numeric
## evaluation_log        2 data.table         list
## call                 14 -none-             call
## params                2 -none-             list
## callbacks             1 -none-             list
## feature_names        16 -none-             character
## nfeatures             1 -none-             numeric
```

```
go_pred_y = predict(go_model_xgboost, go_xgb_test)
mean((go_test_y - go_pred_y)^2)
```

```
## [1] 0.003585083
```

```
RMSE(go_test_y, go_pred_y)
```

```
## [1] 0.05987557
```

```
y_go_test_mean = mean(go_test_y)
x = 1:length(go_test_y)
plot(x, go_test_y, col = "red", type = "l")
lines(x, go_pred_y, col = "blue", type = "l")
```