# Kaggle Kobe Bryant Analysis

Analytics Meetup

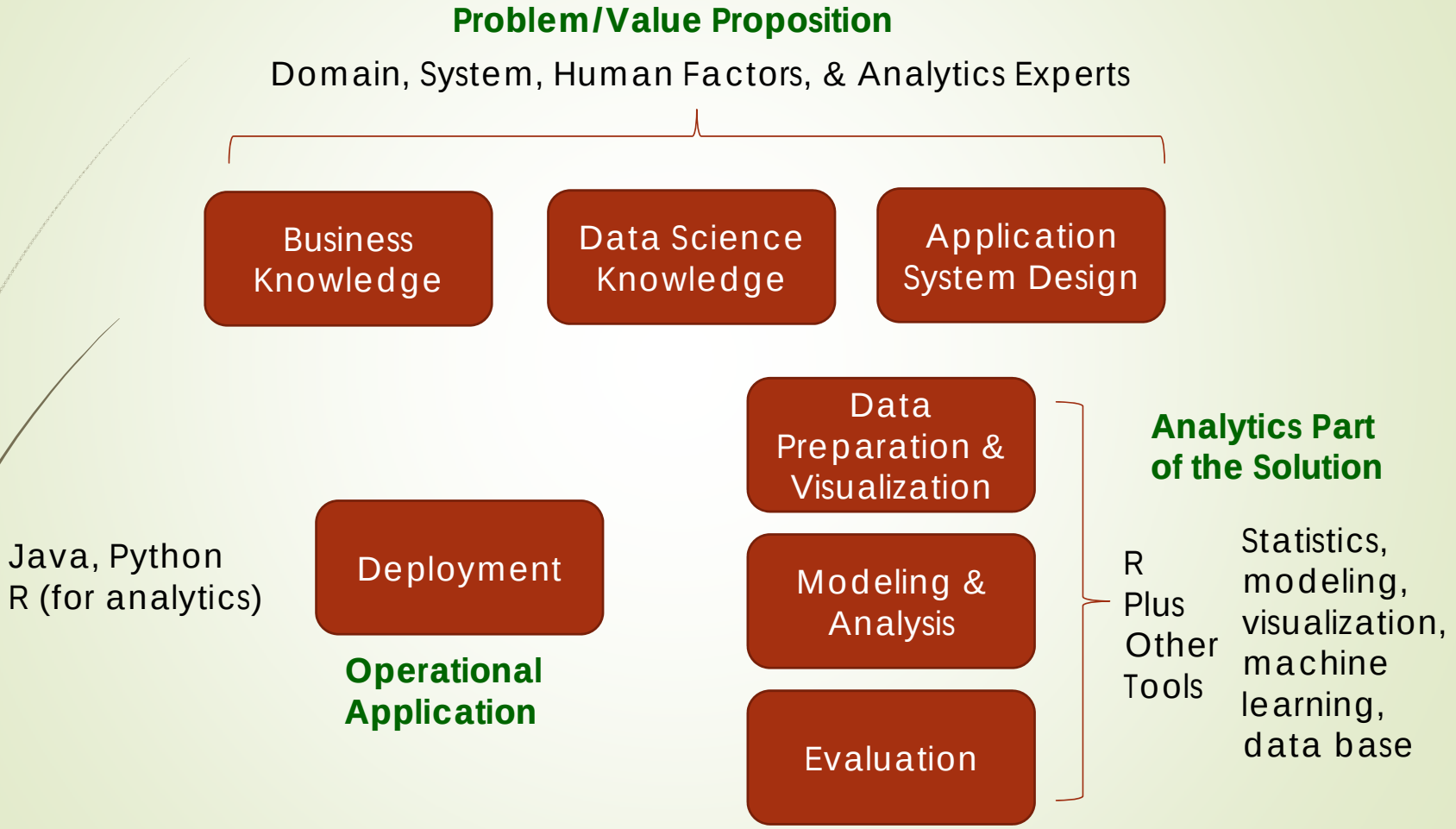
Norm Zeck

# My goals with the project & this talk

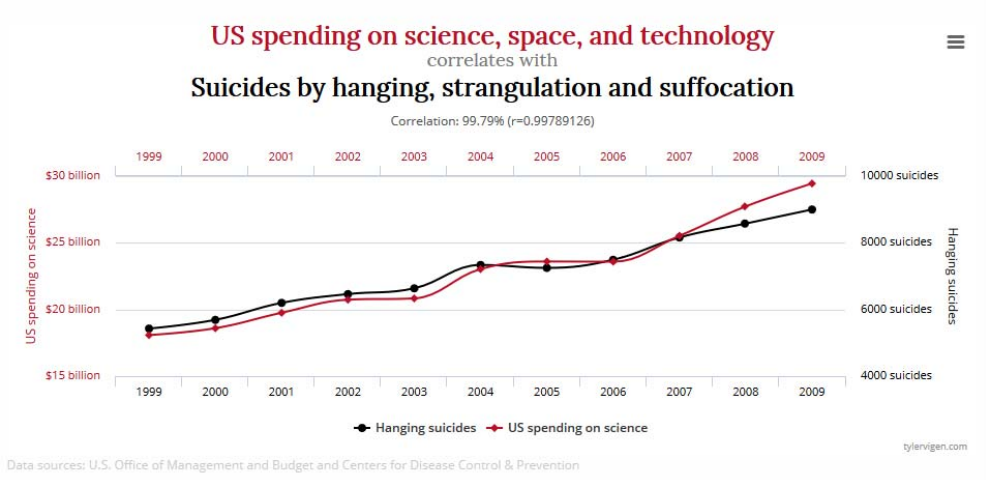
- Project: Educational exercise
  - Experiment:  R, visualization, prediction
    - Caret package, XGBoost
  - Data set that would stress predictive algorithms
  - Choose a set that I had domain knowledge
- Talk: Walk through of a sample data science project
  - Process (future discussion?)
  - Value of knowing the domain
  - Use of visualization & analysis
  - Modeling results
  - Caveat – code needs refactoring from exploratory mode; did not do "leakage" requirement

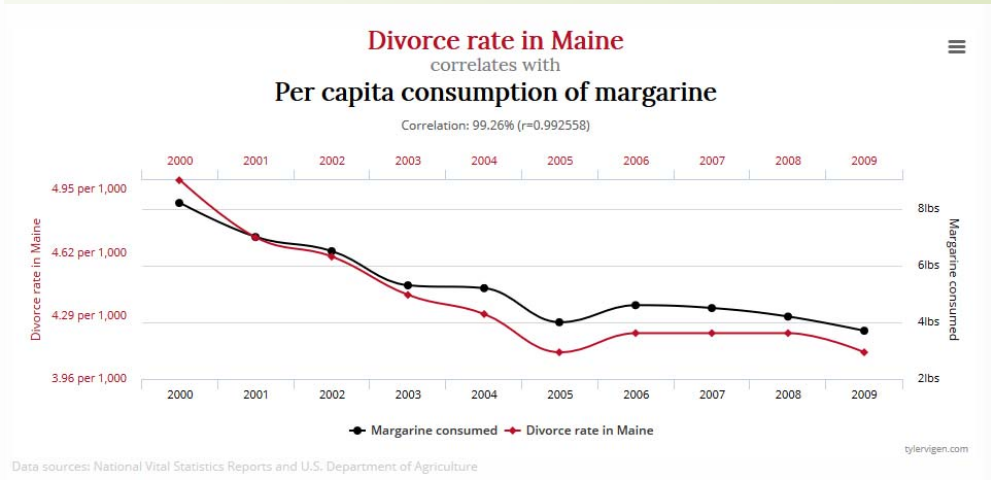
# Data Science Application Design

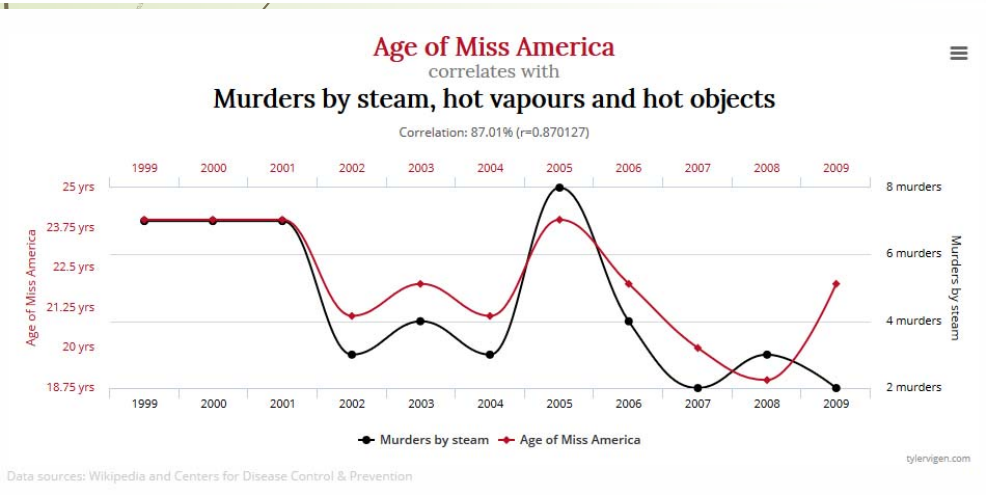
Possible Future Discussion

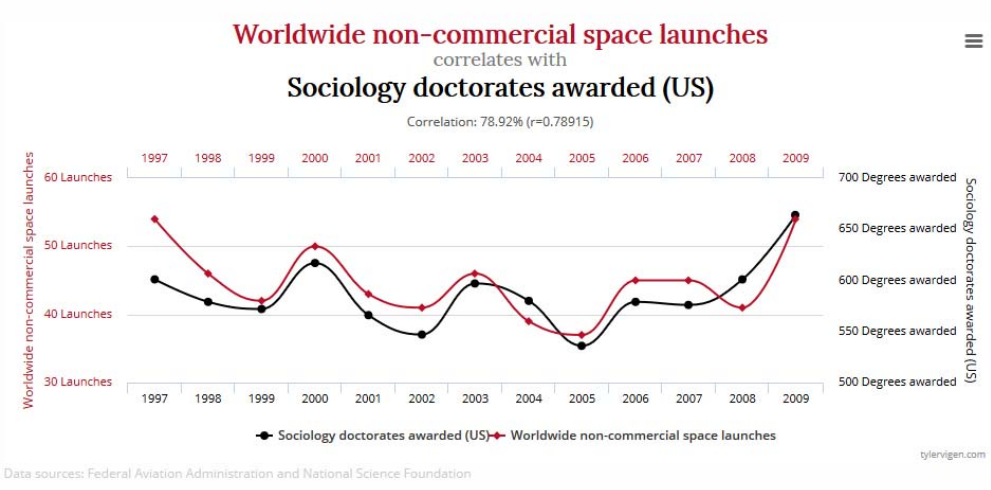


# Importance of domain knowledge



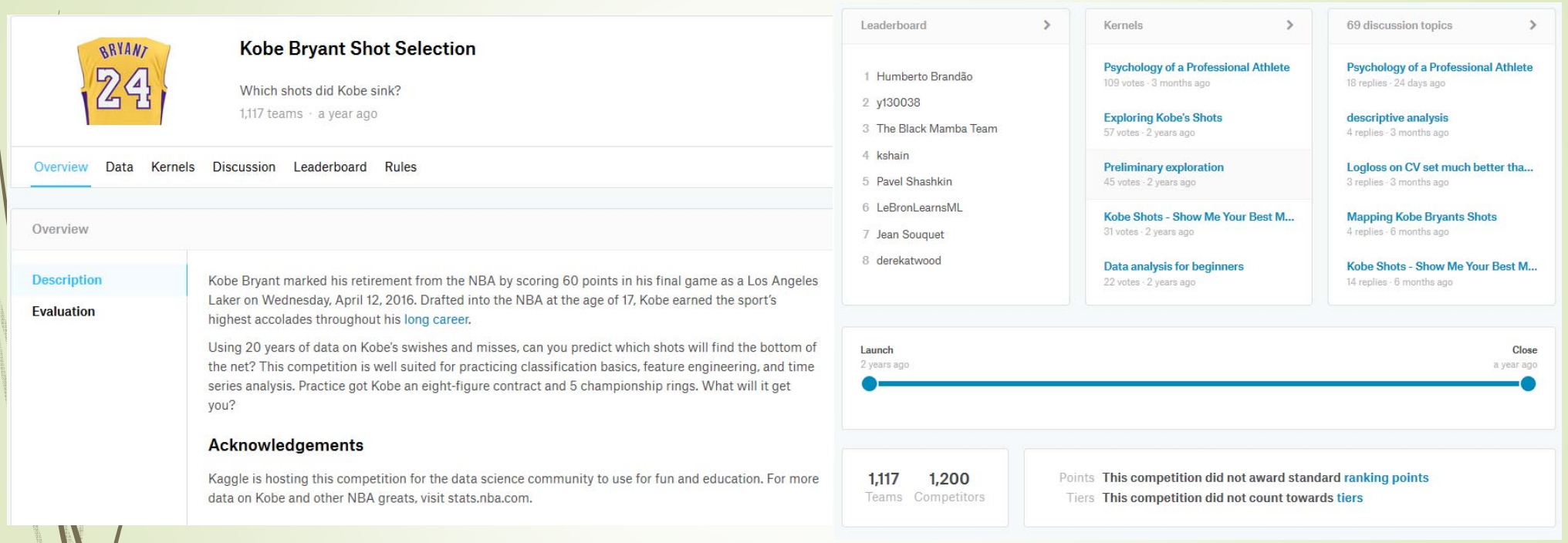




http://www.tylervigen.com/spurious-correlations

# Kaggle Kobe Bryant Shot Selection



Kobe Bryant Shot Selection

Which shots did Kobe sink?

1,117 teams · a year ago

Overview | Data | Kernels | Discussion | Leaderboard | Rules

Overview

Description

Evaluation

Kobe Bryant marked his retirement from the NBA by scoring 60 points in his final game as a Los Angeles Laker on Wednesday, April 12, 2016. Drafted into the NBA at the age of 17, Kobe earned the sport's highest accolades throughout his long career.

Using 20 years of data on Kobe's swishes and misses, can you predict which shots will find the bottom of the net? This competition is well suited for practicing classification basics, feature engineering, and time series analysis. Practice got Kobe an eight-figure contract and 5 championship rings. What will it get you?

### Acknowledgements

Kaggle is hosting this competition for the data science community to use for fun and education. For more data on Kobe and other NBA greats, visit stats.nba.com.

Leaderboard

1 Humberto Brandão
2 y130038
3 The Black Mamba Team
4 kshain
5 Pavel Shashkin
6 LeBronLearnsML
7 Jean Souquet
8 derekatwood

Kernels

Psychology of a Professional Athlete
109 votes · 3 months ago

Exploring Kobe's Shots
57 votes · 2 years ago

Preliminary exploration
45 votes · 2 years ago

Kobe Shots - Show Me Your Best M...
31 votes · 2 years ago

Data analysis for beginners
22 votes · 2 years ago

69 discussion topics

Psychology of a Professional Athlete
18 replies · 24 days ago

descriptive analysis
4 replies · 3 months ago

Logloss on CV set much better tha...
3 replies · 3 months ago

Mapping Kobe Bryants Shots
4 replies · 6 months ago

Kobe Shots - Show Me Your Best M...
14 replies · 6 months ago

Launch
2 years ago

Close
a year ago

1,117 Teams
1,200 Competitors

Points This competition did not award standard ranking points
Tiers This competition did not count towards tiers

# CodeBook

Full Set
30,697 samples, 25 Variables
Training Set (coded)
25697 samples
Test Set (not coded)
5000 samples

| Variable | Info | Type | Grouping |
|---|---|---|---|
| season | Year span like 2000-01, 2015-16; 20 total | Categorical | Date |
| game_date | Date of the game | Date | Date |
| game_event_id | Numbered event in game | Integer | Game |
| game_id | Number assigned to each game | Integer | Game |
| playoffs | Regular or playoff game | Categorical | Game |
| minutes_remaining | Minutes remaining in quarter | Integer | Game Time |
| period | Period. Typically 1-4, but overtime 5,6,7 | Categorical | Game Time |
| seconds_remaining | Seconds remaining in quarter | Integer | Game Time |
| shot_id | Sequential # for each shot | Integer | Index |
| lat | X location | Float | Location |
| loc_x | X location (0.1 ft) | Integer | Location |
| loc_y | Y location (0.1 ft) | Integer | Location |
| lon | Y location | Float | Location |
| shot_distance | Feet from basket, 0 is valid | Integer | Location |
| shot_zone_area | Left, right, center…6 levels | Categorical | Location |
| shot_zone_basic | 7 levels: Above the Break 3; Backcourt; In The Paint (Non-RA - restricted area); Left Corner 3; Right Corner 3; Mid-Range; Restricted Area; | Categorical | Location |
| shot_zone_range | One of 5 zones: backcourt; 24+; 16-24 ft.; 8 to 16; less than 8; | Categorical | Location |
| shot_made_flag | Made/miss, this is what to predict | Categorical | Outcome |
| action_type | Detail shot type. 57 Levels: Reverse Layup Shot; Running Jump Shot; Jump Shot; Slam Dunk Shot… | Categorical | Shot type |
| combined_shot_type | More general shot type, 6 levele: Bank Shot; Dunk; Hook Shot; Jump Shot; Layup; Tip Shot | Categorical | Shot type |
| shot_type | 2 or 3 point | Categorical | Shot type |
| team_id | Lakers | Integer | Team |
| team_name | Lakers | Categorical | Team |
| matchup | Opponent and home vs away | Categorical | Team |
| opponent | Opponent team | Categorical | Team |

# Spatial view of the data

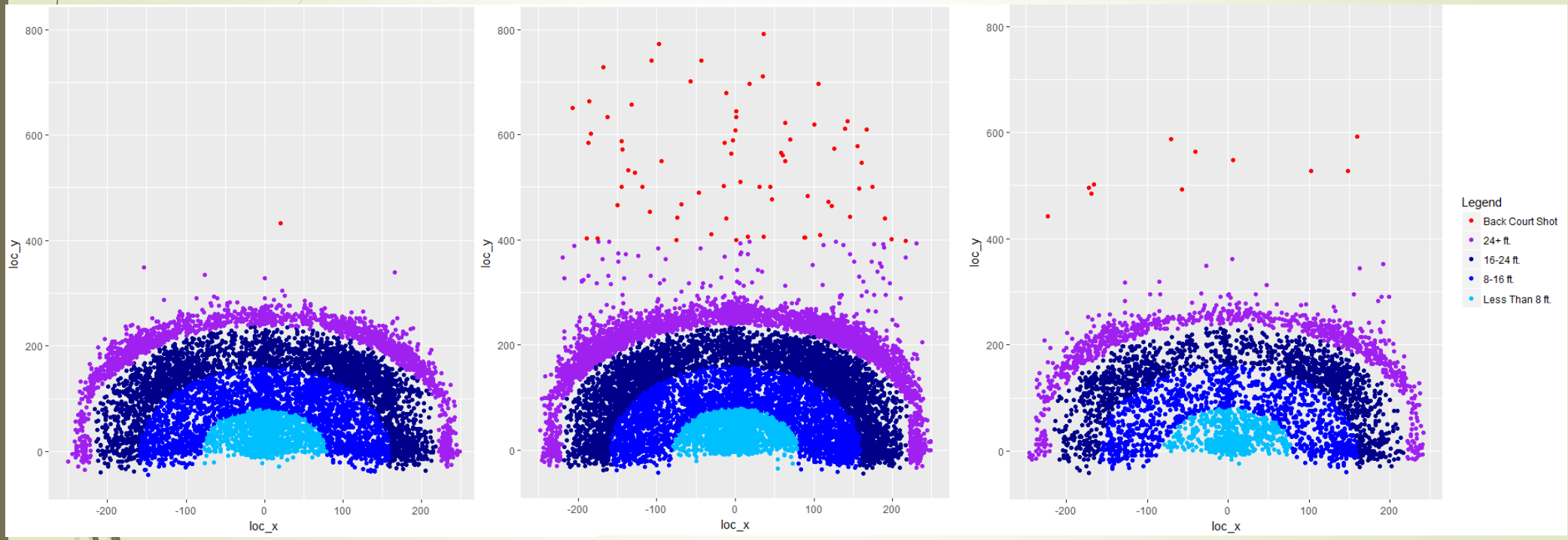
Basket ball court

# Shot by distance zone

Shots Made

Shots Not Made

Test Set




Scale: 1 ~ 0.1 ft

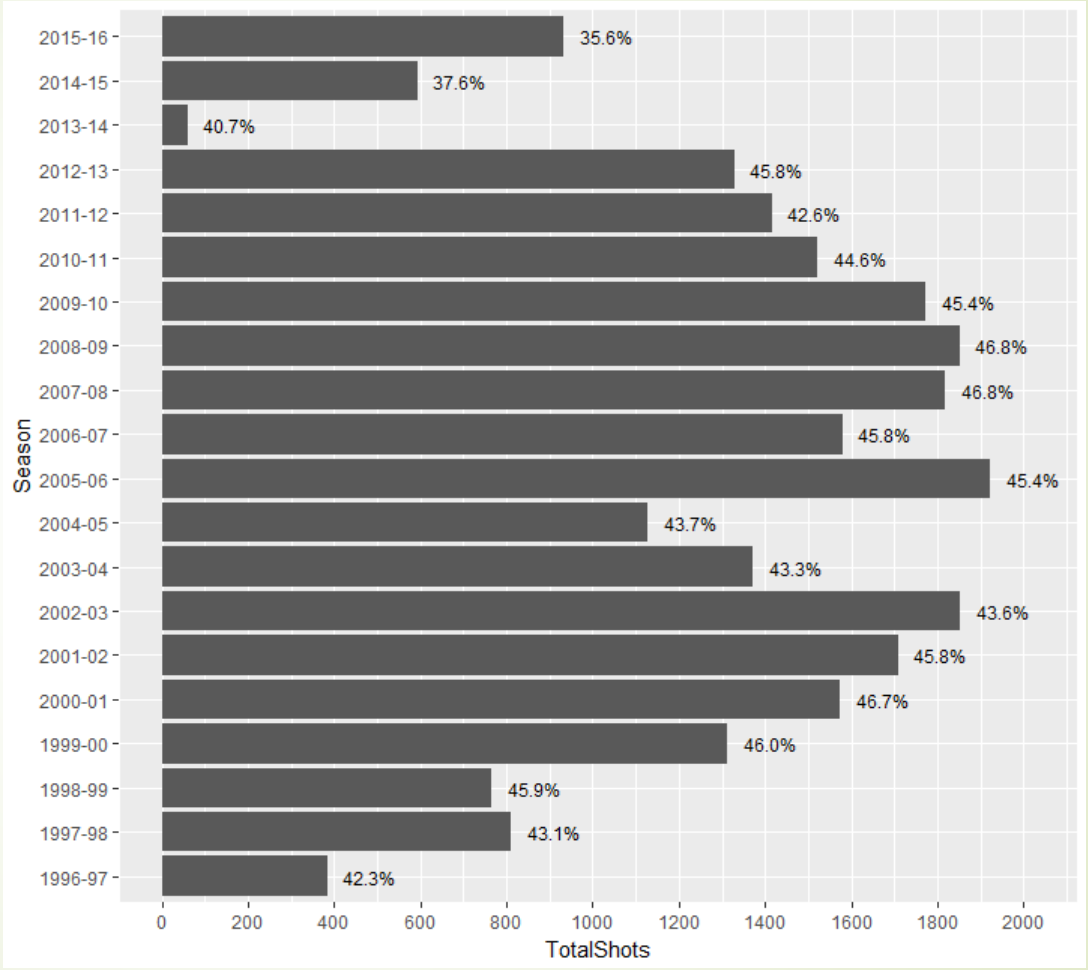
# Exploratory visualization of the data

Focus on percent made, number of shots by categorical variable

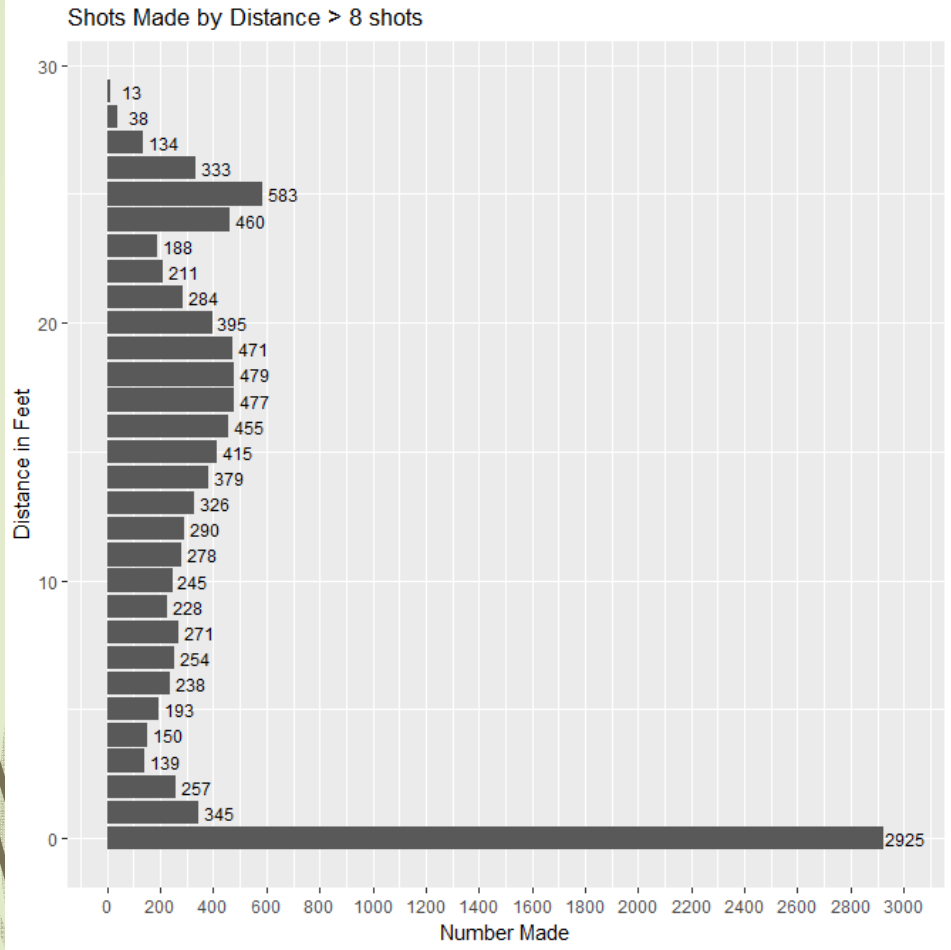
# Shots by Season, Percent made

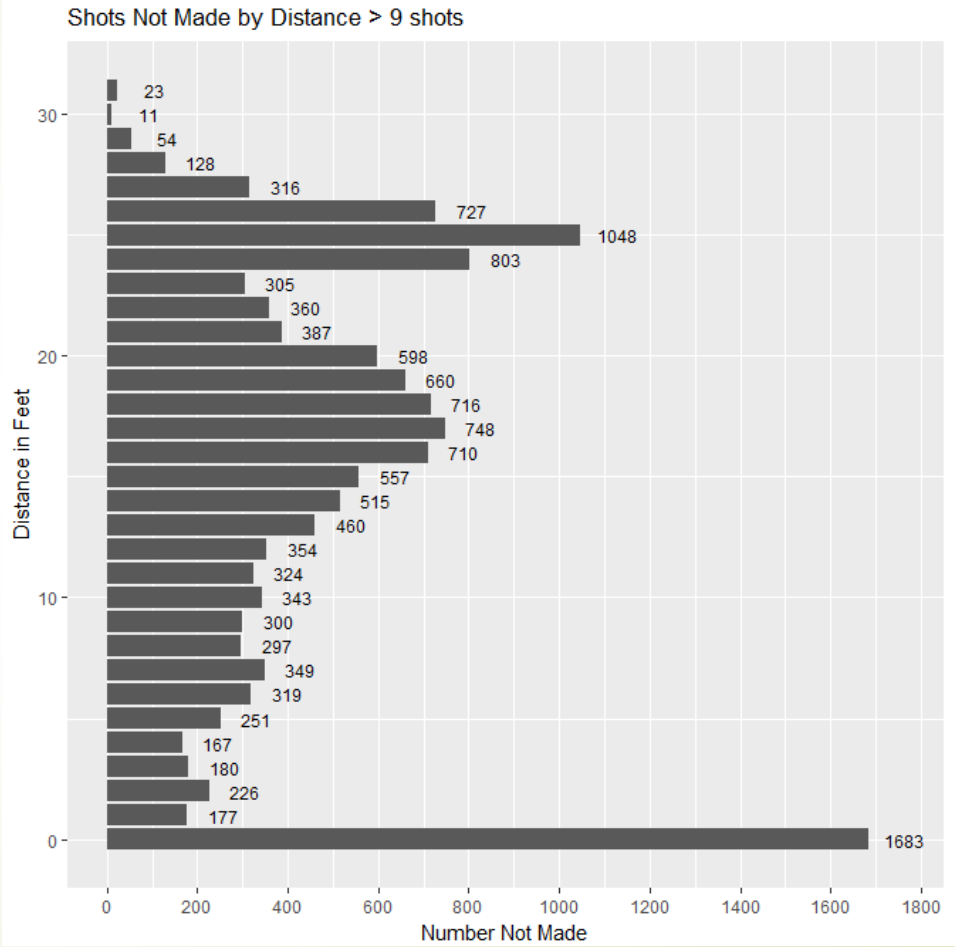
2013 Injury

Percent made ranges from 42.3% to 46.8% (4.5% delta) before injury

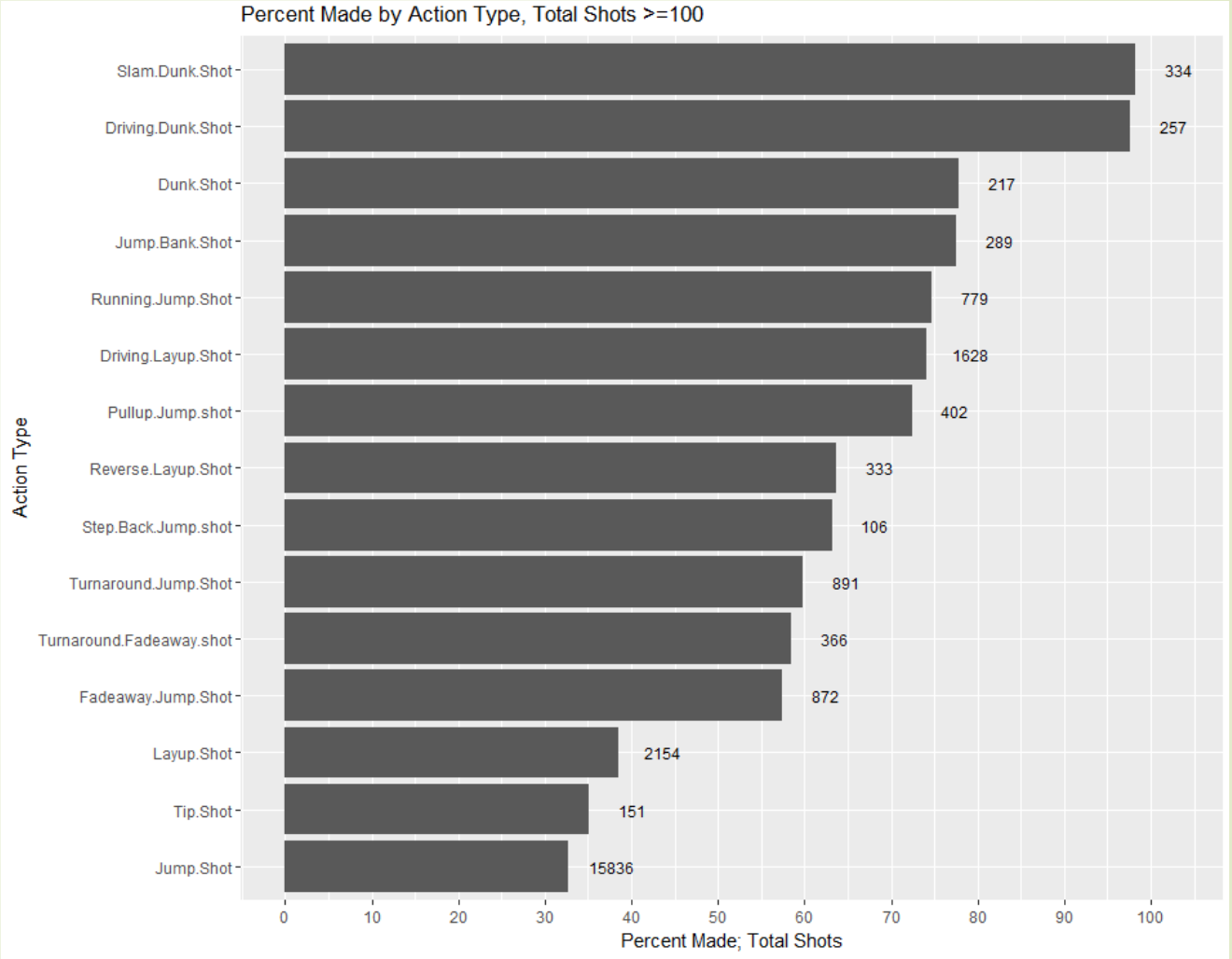


# Shots by Distance

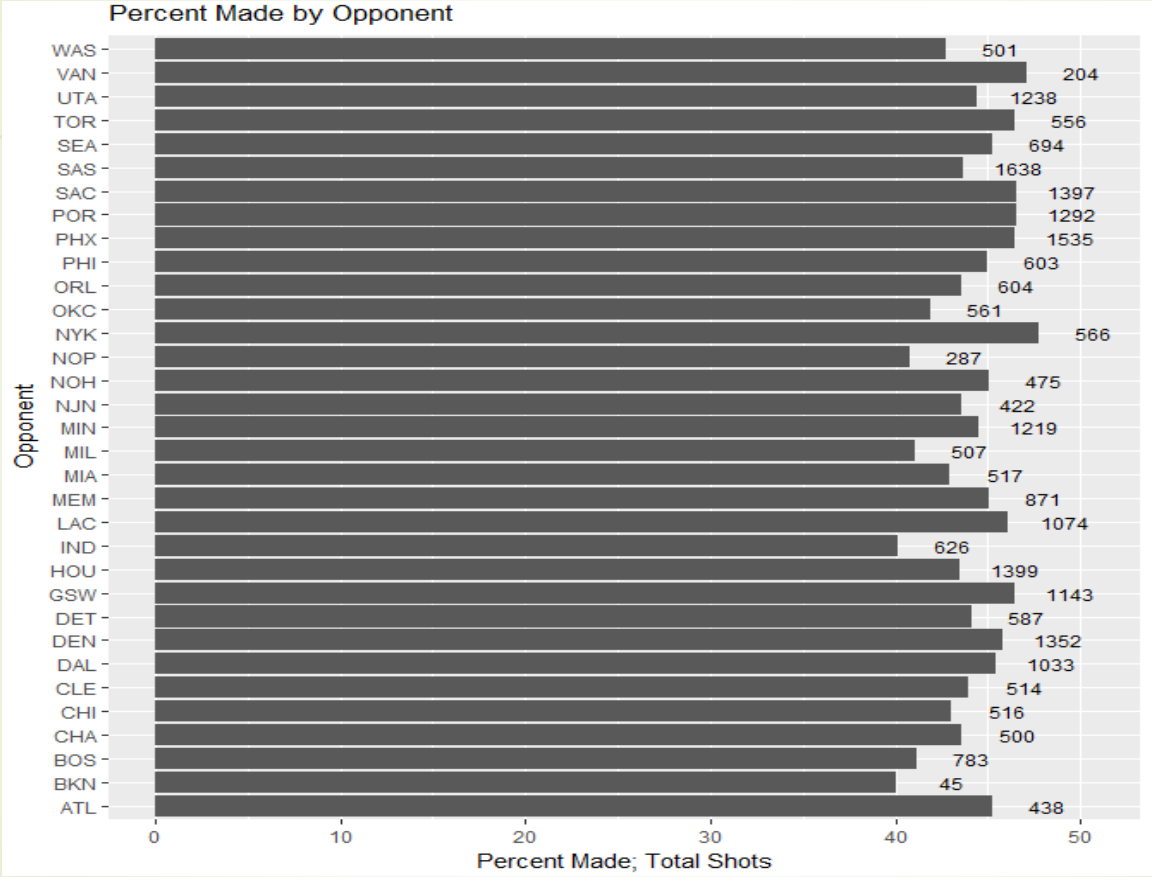


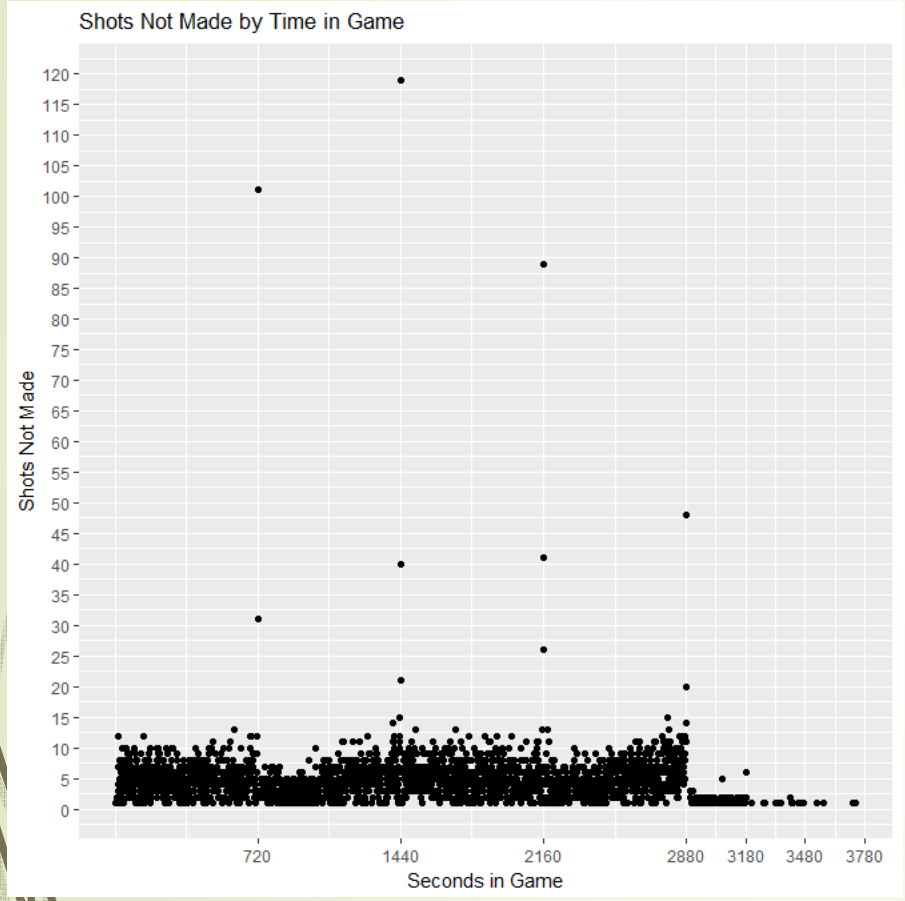
# Action Type > 100 shots

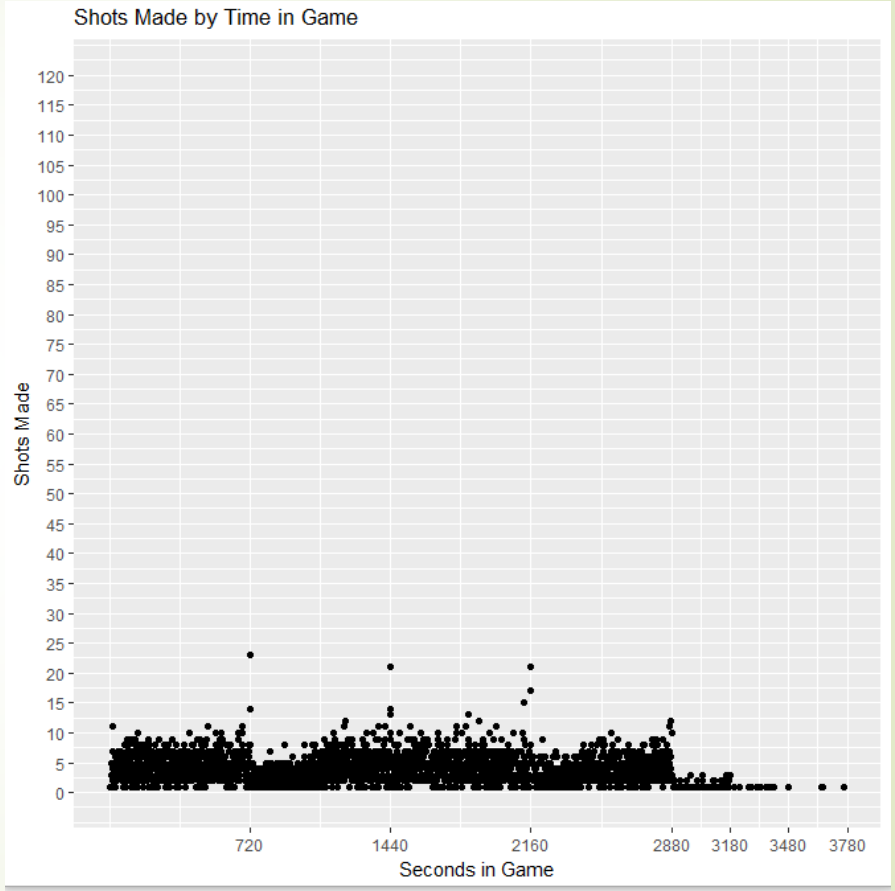


# Shots by Opponent, Percent Made



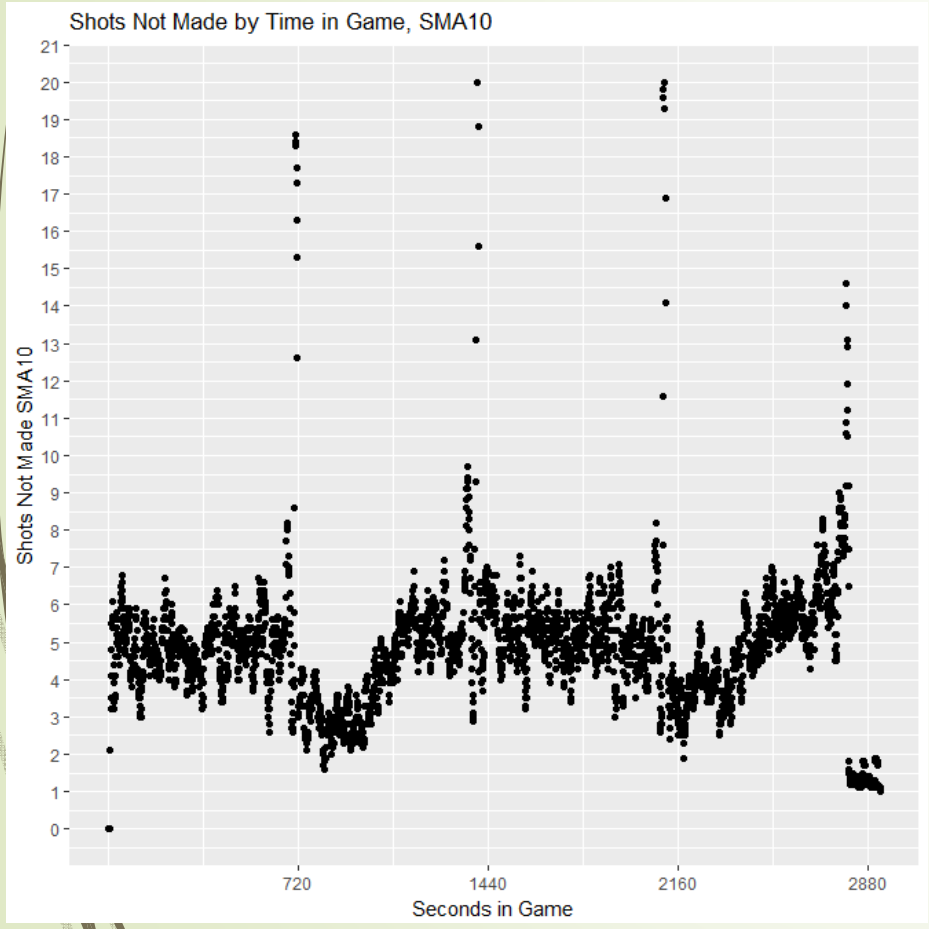
# Shots by time in game

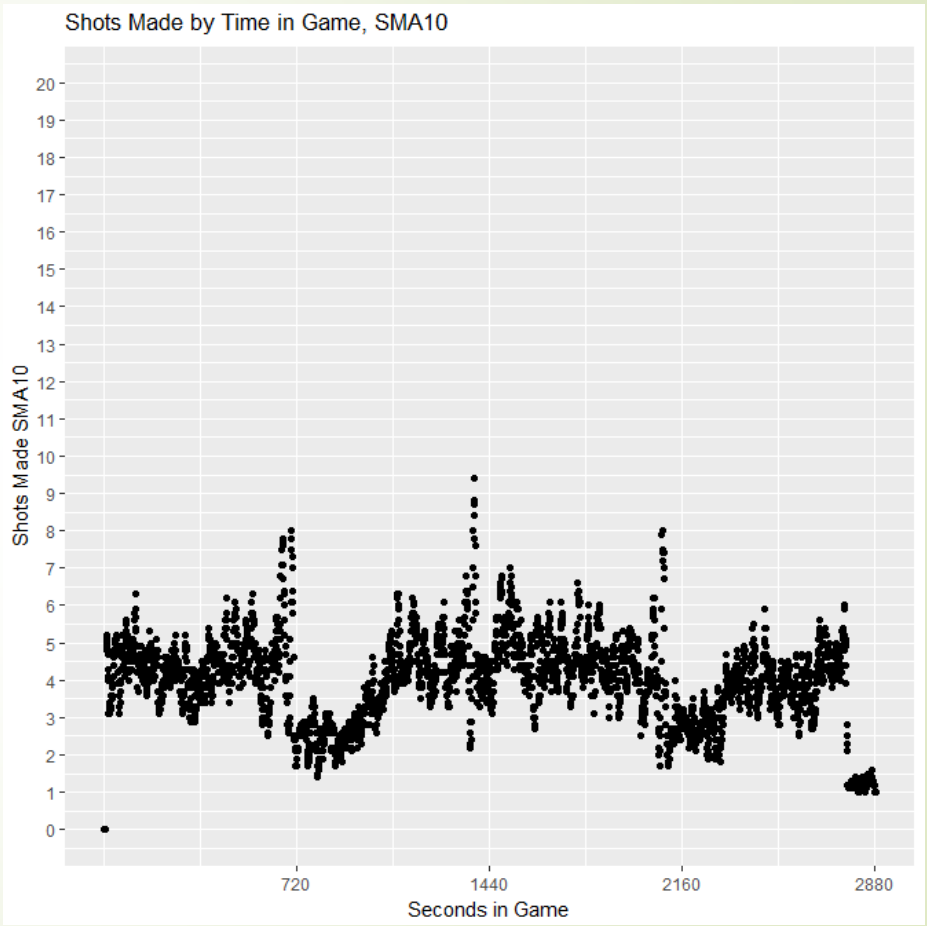


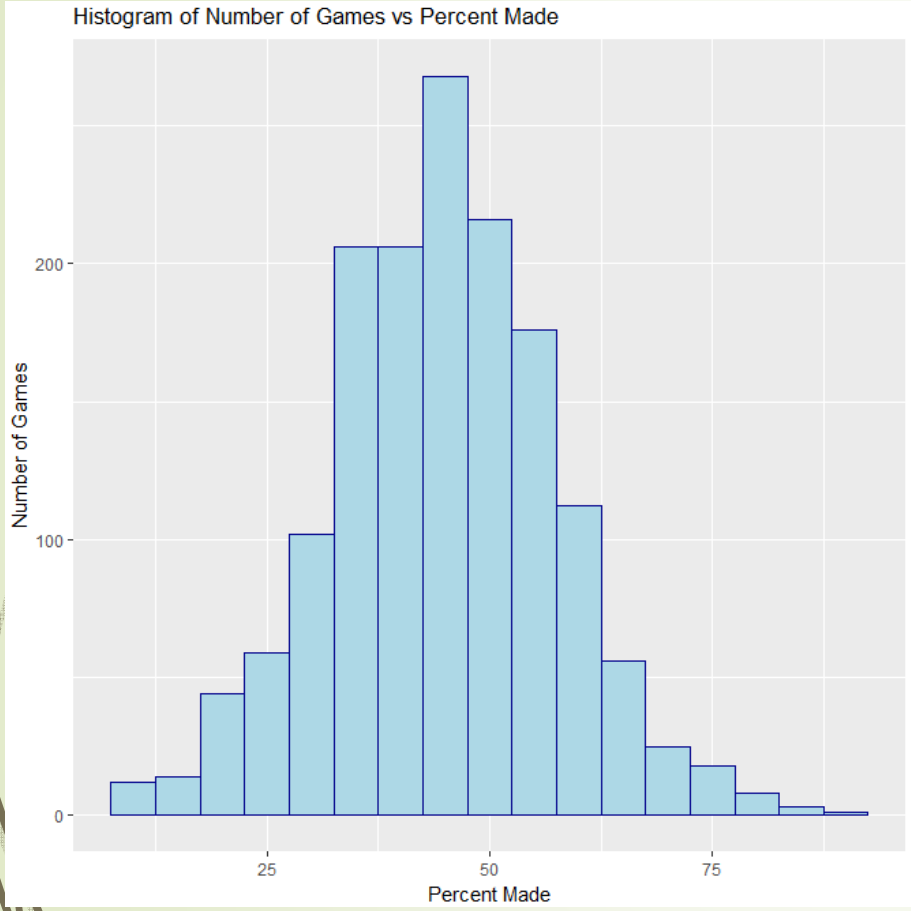
# Shots by time in game

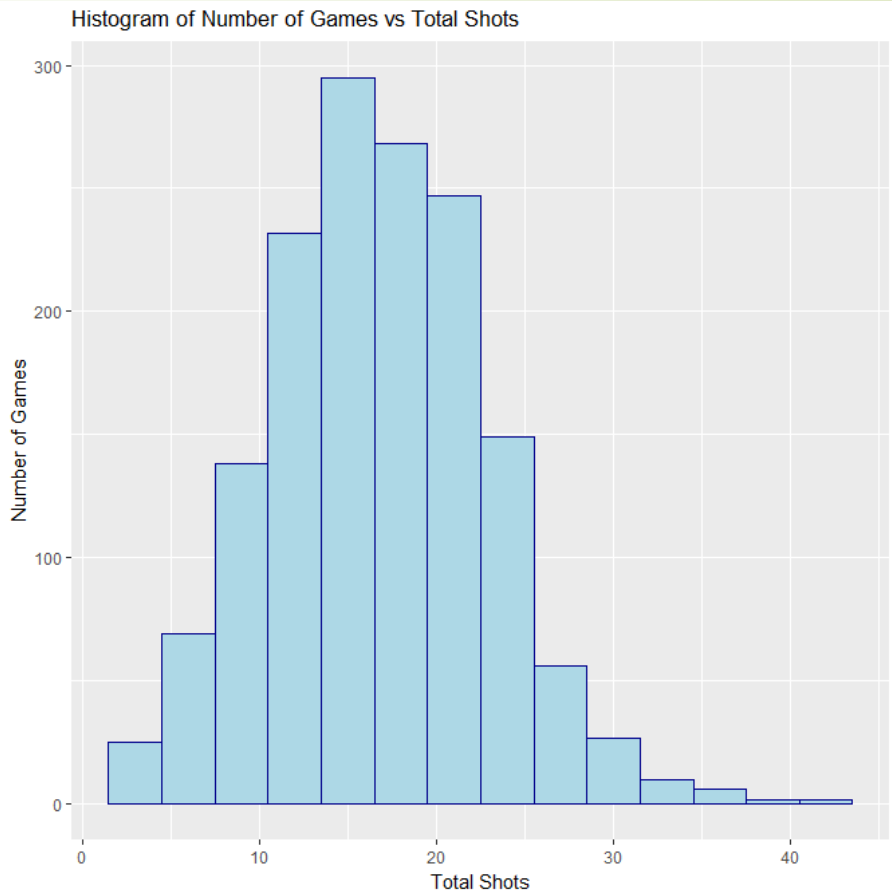
## Simple moving average, 10 seconds



# Shots by game



# Which Variables to Use for Prediction?

Build on learnings from visualization & analysis

# Chosen Variable Set

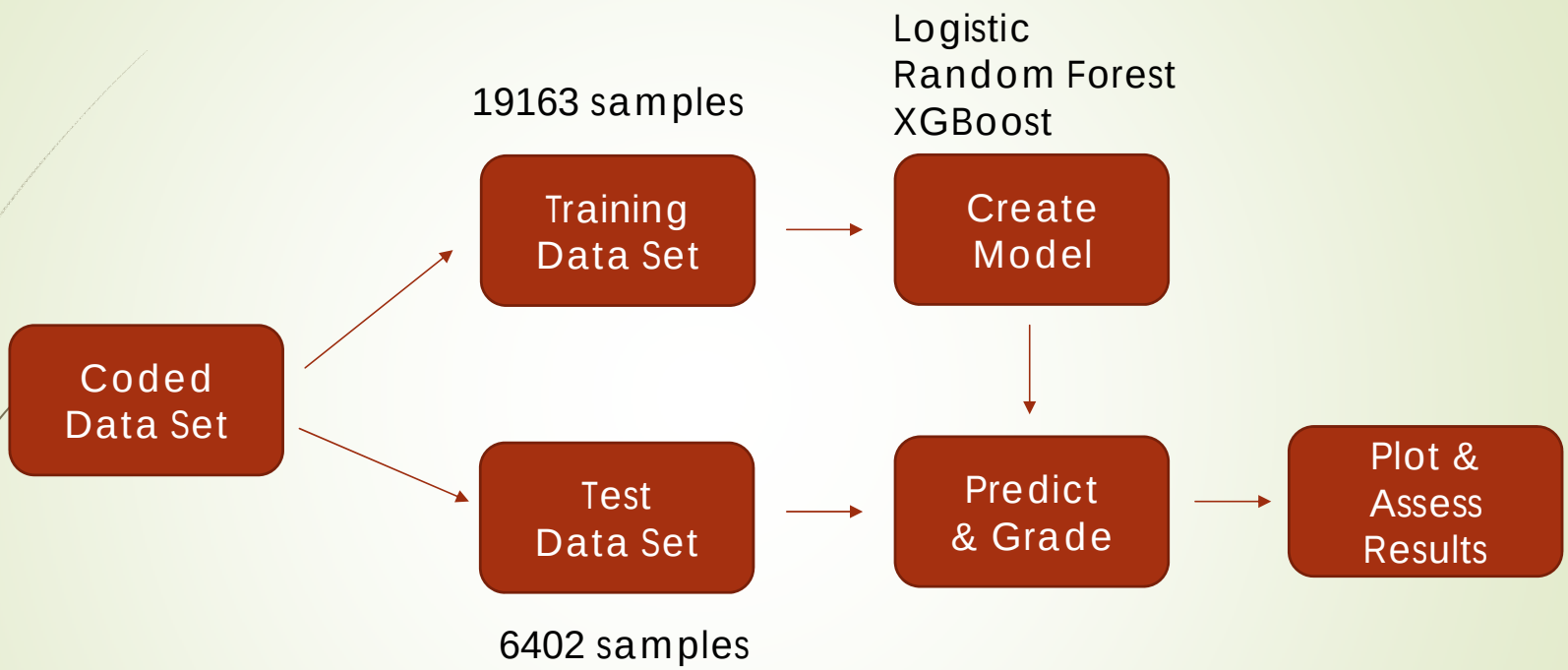
| Variable | Info | Type | Grouping | Prediction |
|---|---|---|---|---|
| season | Year span like 2000-01, 2015-16; 20 total | Categorical | Date | Y |
| game_date | *Date of the game* | *Date* | *Date* | *N* |
| game_event_id | *Numbered event in game* | *Integer* | *Game* | *N* |
| game_id | Number assigned to each game | Integer | Game | Y |
| playoffs | *Regular or playoff game* | *Categorical* | *Game* | *N* |
| minutes_remaining | *Minutes remaining in quarter* | *Integer* | *Game Time* | *N* |
| period | *Period. Typically 1-4, but overtime 5,6,7* | *Categorical* | *Game Time* | *N* |
| seconds_remaining | *Seconds remaining in quarter* | *Integer* | *Game Time* | *N* |
| shot_id | *Sequential # for each shot* | *Integer* | *Index* | *N* |
| lat | *X location* | *Float* | *Location* | *N* |
| loc_x | X location (0.1 ft) | Integer | Location | Y |
| loc_y | Y location (0.1 ft) | Integer | Location | Y |
| lon | *Y location* | *Float* | *Location* | *N* |
| shot_distance | Feet from basket, 0 is valid | Integer | Location | Y |
| shot_zone_area | Left, right, center...6 levels | Categorical | Location | Y |
| shot_zone_basic | 7 levels: Above the Break 3; Backcourt; In The Paint (Non-RA - restricted area); Left Corner 3; Right Corner 3; Mid-Range; Restricted Area; | Categorical | Location | Y |
| shot_zone_range | One of 5 zones: backcourt; 24+; 16-24 ft.; 8 to 16; less than 8; | Categorical | Location | Y |
| shot_made_flag | Made/miss, this is what to predict | Categorical | Outcome | Y |
| action_type | Detail shot type. 57 Levels: Reverse Layup Shot; Running Jump Shot; Jump Shot; Slam Dunk Shot... | Categorical | Shot type | Y |
| combined_shot_type | *More general shot type, 6 levele: Bank Shot; Dunk; Hook Shot; Jump Shot; Layup; Tip Shot* | *Categorical* | *Shot type* | *N* |
| shot_type | 2 or 3 point | Categorical | Shot type | Y |
| team_id | *Lakers* | *Integer* | *Team* | *N* |
| team_name | *Lakers* | *Categorical* | *Team* | *N* |
| matchup | *Opponent and home vs away* | *Categorical* | *Team* | *N* |
| opponent | *Opponent team* | *Categorical* | *Team* | *N* |
| game_time | Seconds in the game | Float | Game Time | Y |
| game_pct | Percent made for each game | Float | Game | Y |
| shots_made_by_second | Number of shots made by second in the game | Float | Game | Y |
| shots_not_made_by_second | Number of shots not made by second in the game | Float | Game | Y |

Added Variables

# Predictions

Logistic, Random Forest (Caret), XGBoost, Also tested randomForest

# Modeling Process



# Confusion Matrix & Accuracy

| | Logistic | | xgboost | | random forest (caret) | | randomForest | |
|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 |
| 0 | 2875 | 666 | 2896 | 645 | 2921 | 620 | 3151 | 389 |
| 1 | 1171 | 1690 | 1081 | 1780 | 1206 | 1655 | 2038 | 816 |
| Accuracy | 71.3% | | 73.0% | | 71.5% | | 62.0% | |
| Time (sec) | 2.39 | | 1.14 | | 9813 | | 7.14 | |

Accuracy = (TP + TN)/(TP + TN + FP + FN)

| | | y Predicted | |
|---|---|---|---|
| | | 0 | 1 |
| y Actual | 0 | True Negative | False Positive |
| | 1 | False Negative | True Positive |

9813 seconds = 2.7 hrs

# Variable Importance

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

## Logistic Regression

| | Estimate | Std. Error | z value | Pr(>\|z\|) | |
|---|---|---|---|---|---|
| (Intercept) | -1.08E+01 | 1.44E+02 | -0.075 | 0.94028 | |
| action_typeDriving.Jump.shot | -2.95E+00 | 7.35E-01 | -4.02 | 5.83E-05 | *** |
| action_typeFadeaway.Jump.Shot | -2.30E+00 | 5.50E-01 | -4.178 | 2.94E-05 | *** |
| action_typeHook.Shot | -3.20E+00 | 6.18E-01 | -5.183 | 2.19E-07 | *** |
| action_typeJump.Shot | -3.46E+00 | 5.44E-01 | -6.374 | 1.85E-10 | *** |
| action_typeLayup.Shot | -3.11E+00 | 5.24E-01 | -5.927 | 3.09E-09 | *** |
| action_typeReverse.Layup.Shot | -2.39E+00 | 5.39E-01 | -4.438 | 9.07E-06 | *** |
| action_typeStep.Back.Jump.shot | -2.06E+00 | 5.95E-01 | -3.466 | 0.000528 | *** |
| action_typeTip.Shot | -3.33E+00 | 5.62E-01 | -5.927 | 3.09E-09 | *** |
| action_typeTurnaround.Fadeaway.shot | -2.01E+00 | 5.60E-01 | -3.589 | 0.000332 | *** |
| action_typeTurnaround.Jump.Shot | -2.27E+00 | 5.49E-01 | -4.124 | 3.72E-05 | *** |
| shots_notmade_by_second | -7.34E-02 | 3.13E-03 | -23.422 | < 2e-16 | *** |
| shots_made_by_second | 2.31E-01 | 7.76E-03 | 29.753 | < 2e-16 | *** |
| game_pct | 4.25E-02 | 1.54E-03 | 27.687 | < 2e-16 | *** |
| shot_distance | 2.36E-02 | 8.89E-03 | 2.659 | 0.007845 | ** |
| action_typeAlley.Oop.Layup.shot | -1.78E+00 | 6.12E-01 | -2.903 | 0.003692 | ** |
| action_typeDriving.Hook.Shot | -2.12E+00 | 8.18E-01 | -2.59 | 0.009611 | ** |
| action_typeDriving.Layup.Shot | -1.61E+00 | 5.26E-01 | -3.056 | 0.00224 | ** |
| action_typeDunk.Shot | -1.48E+00 | 5.56E-01 | -2.65 | 0.008043 | ** |
| action_typeFinger.Roll.Shot | -2.31E+00 | 7.19E-01 | -3.213 | 0.001312 | ** |
| action_typePullup.Bank.shot | -2.28E+00 | 8.57E-01 | -2.655 | 0.007924 | ** |
| action_typePullup.Jump.shot | -1.62E+00 | 5.62E-01 | -2.877 | 0.004018 | ** |
| action_typeRunning.Jump.Shot | -1.43E+00 | 5.52E-01 | -2.594 | 0.009478 | ** |
| action_typeRunning.Layup.Shot | -1.84E+00 | 6.23E-01 | -2.958 | 0.003098 | ** |
| action_typeTurnaround.Hook.Shot | -2.51E+00 | 9.64E-01 | -2.6 | 0.009321 | ** |
| shot_zone_basicLeft Corner 3 | 4.00E-01 | 1.99E-01 | 2.011 | 0.044353 | * |
| action_typeDriving.Finger.Roll.Shot | -1.27E+00 | 6.35E-01 | -2.001 | 0.045363 | * |
| action_typeDriving.Reverse.Layup.Shot | -1.42E+00 | 6.00E-01 | -2.367 | 0.017939 | * |
| action_typeFinger.Roll.Layup.Shot | -1.62E+00 | 8.00E-01 | -2.024 | 0.042991 | * |
| action_typeFloating.Jump.shot | -1.49E+00 | 6.07E-01 | -2.445 | 0.014487 | * |
| action_typeJump.Bank.Shot | -1.30E+00 | 5.71E-01 | -2.279 | 0.022687 | * |
| action_typePutback.Dunk.Shot | -3.16E+00 | 1.53E+00 | -2.066 | 0.038864 | * |
| action_typeJump.Hook.Shot | -1.56E+00 | 8.60E-01 | -1.809 | 0.070414 | . |
| action_typePutback.Layup.Shot | -1.91E+00 | 1.03E+00 | -1.862 | 0.062568 | . |
| action_typeTurnaround.Bank.shot | -1.26E+00 | 6.69E-01 | -1.88 | 0.060097 | . |

## XGBoost

| | Feature | Gain | Cover | Frequency |
|---|---|---|---|---|
| 1 | action_type | 0.28415 | 0.20674 | 0.08803 |
| 2 | game_pct | 0.16535 | 0.17451 | 0.15479 |
| 3 | shots_made_by_second | 0.16297 | 0.19144 | 0.14528 |
| 4 | shots_notmade_by_second | 0.15386 | 0.17723 | 0.10840 |
| 5 | shot_distance | 0.05356 | 0.05951 | 0.06789 |
| 6 | loc_y | 0.04793 | 0.06090 | 0.10840 |
| 7 | game_time | 0.04733 | 0.04359 | 0.13193 |
| 8 | loc_x | 0.03919 | 0.04697 | 0.08984 |
| 9 | season | 0.02908 | 0.02497 | 0.07422 |
| 10 | shot_zone_basic | 0.00580 | 0.00570 | 0.01199 |
| 11 | shot_zone_range | 0.00536 | 0.00416 | 0.00498 |
| 12 | shot_zone_area | 0.00499 | 0.00349 | 0.01313 |
| 13 | shot_type | 0.00041 | 0.00080 | 0.00113 |

## Random Forest (Caret)

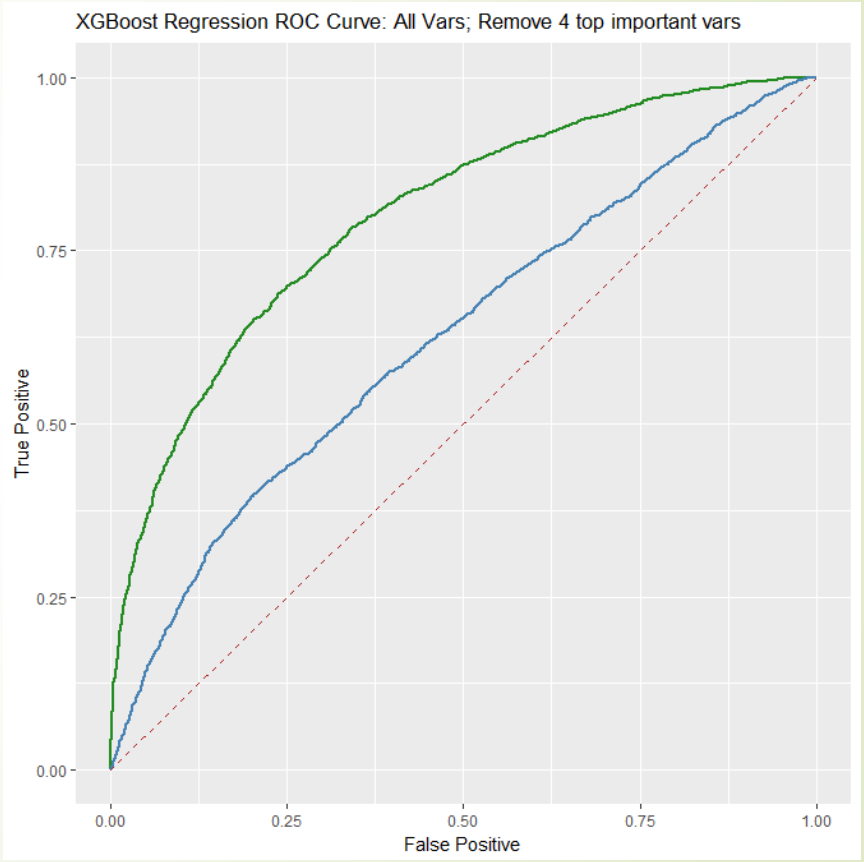
| | MeanDecreaseAccuracy |
|---|---|
| shots_notmade_by_second | 26.27371269 |
| shots_made_by_second | 24.3478625 |
| action_typeJump.Shot | 23.96860105 |
| action_typeLayup.Shot | 22.40470404 |
| game_pct | 22.11663757 |
| loc_x | 12.53466977 |
| action_typeSlam.Dunk.Shot | 11.86498281 |
| loc_y | 11.47755651 |
| shot_distance | 10.58029387 |
| action_typeDriving.Dunk.Shot | 10.36861343 |
| action_typePullup.Jump.shot | 7.372344572 |
| action_typeRunning.Jump.Shot | 6.258553183 |
| action_typeTip.Shot | 5.602478132 |

# Model support and comparison

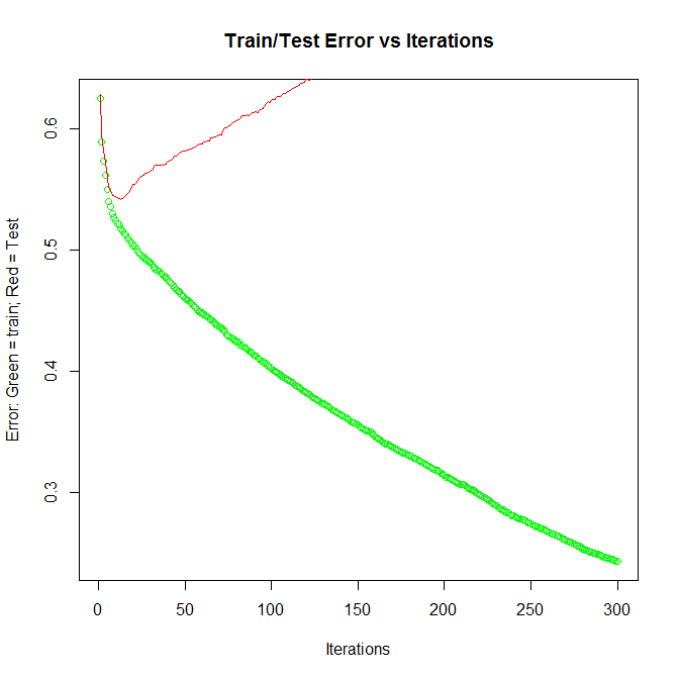
## One-Hot Encoding; ROC (Receiver Operating Characteristic)

| Var1 | Var2 | Outcome |
|---|---|---|
| 1.20 | Cat1 | Out1 |
| 1.30 | Cat2 | Out2 |
| 5.00 | Cat1 | Out3 |
| 10.40 | Cat4 | Out4 |

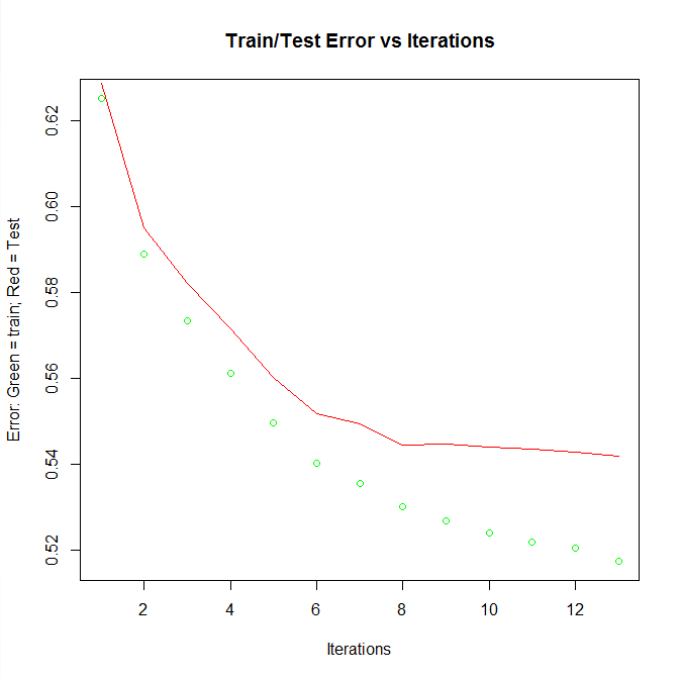
| Var1 | Cat1 | Cat2 | Cat4 | Outcome |
|---|---|---|---|---|
| 1.20 | 1 | 0 | 0 | Out1 |
| 1.30 | 0 | 1 | 0 | Out2 |
| 5.00 | 1 | 0 | 0 | Out3 |
| 10.40 | 0 | 0 | 1 | Out4 |



# XGBoost Parameter Tuning




Eta=0.35, ltr=300
Accuracy=66.2%




Eta=0.35, ltr=13
Accuracy=72.5%

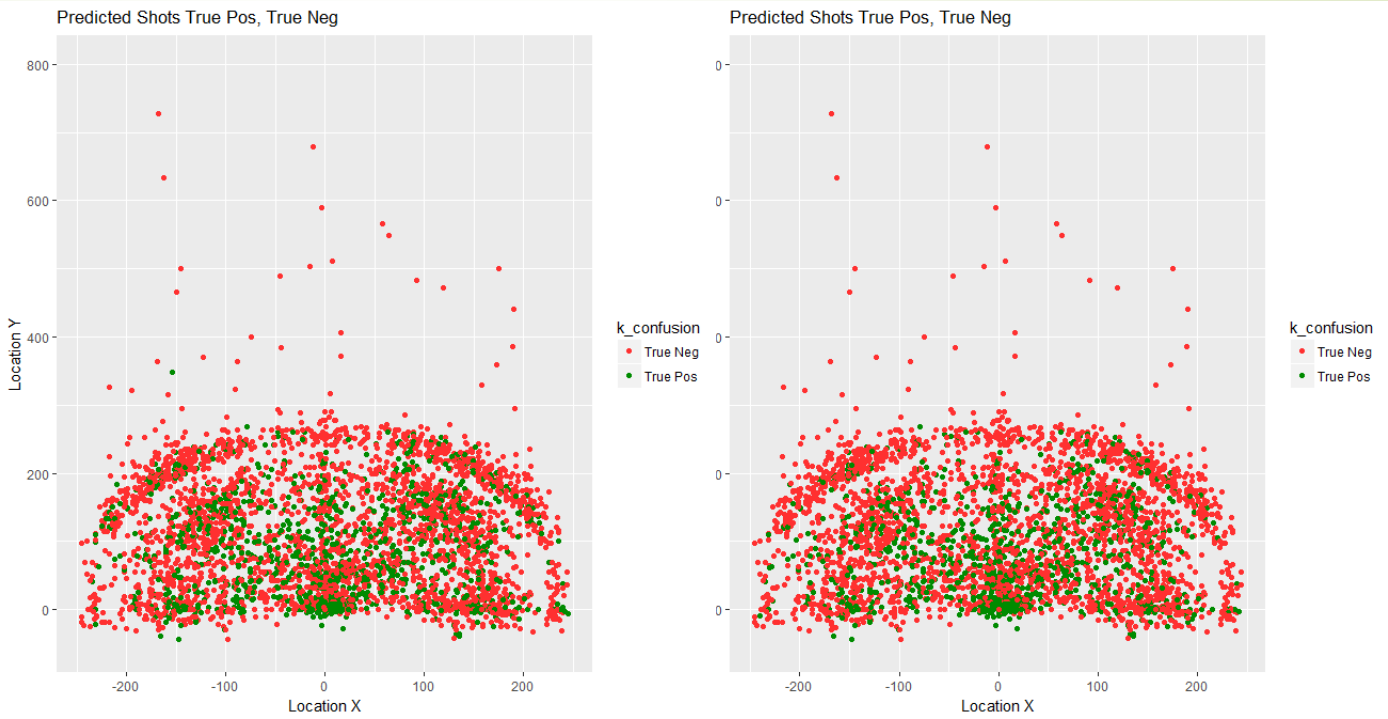
```
xg_error[xg_error$test_logloss == min(xg_error$test_logloss),]

      iter  train_logloss  test_logloss
13    13       0.517244     0.541837
```

# True Positive & Negative

Logistic

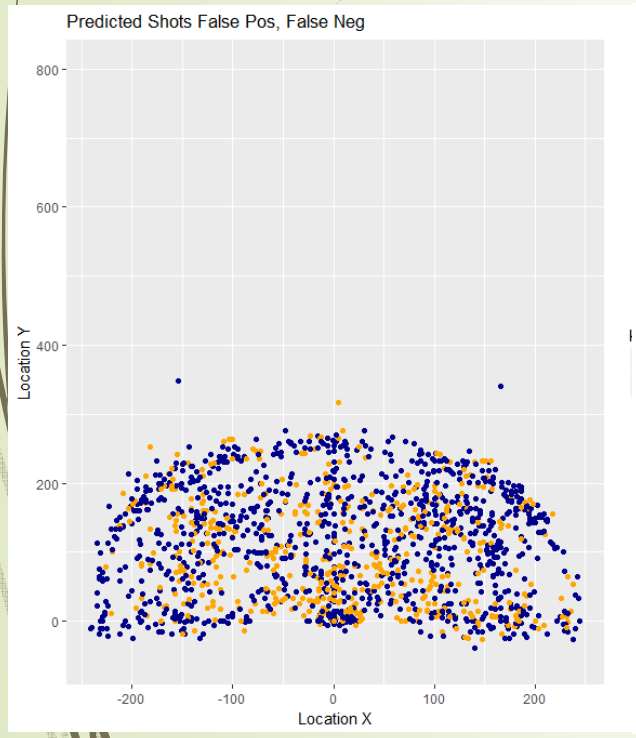

XGBoost



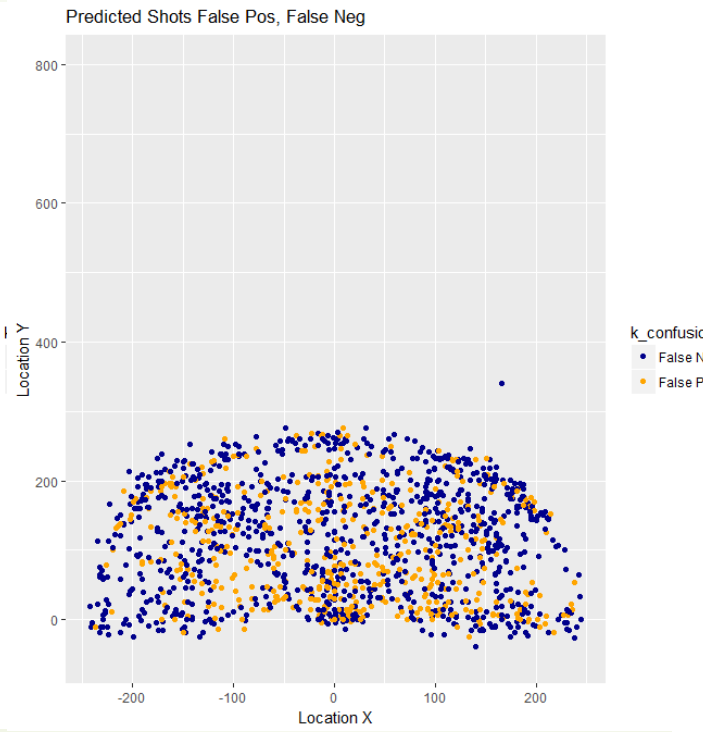

Caret(Random Forest)

# False Positive & Negative

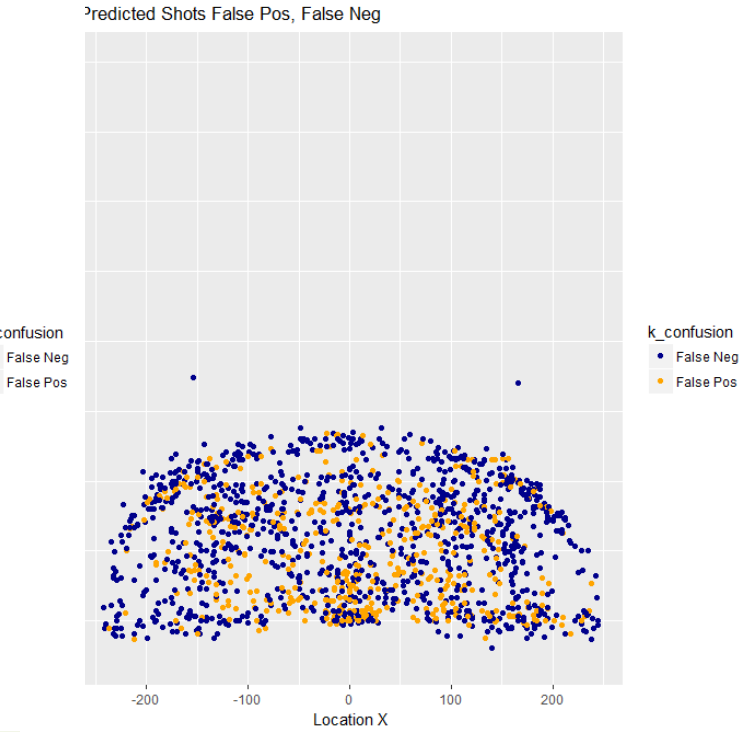
Logistic




XGBoost




Caret(Random Forest)



# Summary & Learning

- Data Science Project
  - Visualization and analysis yielded new variables that also were high importance in the models
  - Generating many slices of the data helped in exploration process
    - Minus – lots of variables and data frames
- R
  - New use of "intersection". Useful for categorical/factor variables.
  - Categories/Factors are stored independent of changes to the samples
    - randomForest only allowed 53 categories per factor variable. action_type has 57.
    - Using a new as.factor() did not work to reset the factors
    - Had to use as.character(), then as.factor() to reset the list

# Summary & Learning

- Models
  - Given information contained in the independent variables, models topped out at ~70%
    - Models needed more information that directed successful shots (True Positive)
    - Since his percent made was from 42% to 47% there is a small real bias toward missing a shot. Models do better at predicting missed shots.
  - New use of xgboost. Impressive both in performance and accuracy, tuning
  - Surprised that logistic regression did as well compared to decision trees.
  - Caret random forest worked well. Used in the past.
    - Slow to build a model, but often that is ok as prediction is fast
  - randomForest disappointed, fast, but low accuracy…back burner.
  - Tuning in all cases was less obvious for many parameters.

# Backup

# Code and Data File Index

| | |
|---|---|
| kobe_xgboost.R | XGBoost Model |
| kobeinit.R | Initialization and data maniplulation |
| kobe_explore.R | Visualization of data set |
| kobe_logistic.R | Logistic Model |
| kobe_caretrf.R | Caret Random Forest Model |
| kobe_func.R | Utility functions |
| kobeinfo-v2.xlsx | Excel file with info on the data set and model results |
| bbcourt.jpg | Picture of basketball court with dimensions |
| KobeBryant.txt | Some info on the data set from kaggle |
| data.csv | Data set - you need to get this from kaggle. Sign up is free, search for "Kobe" on their site will get you to the page. |

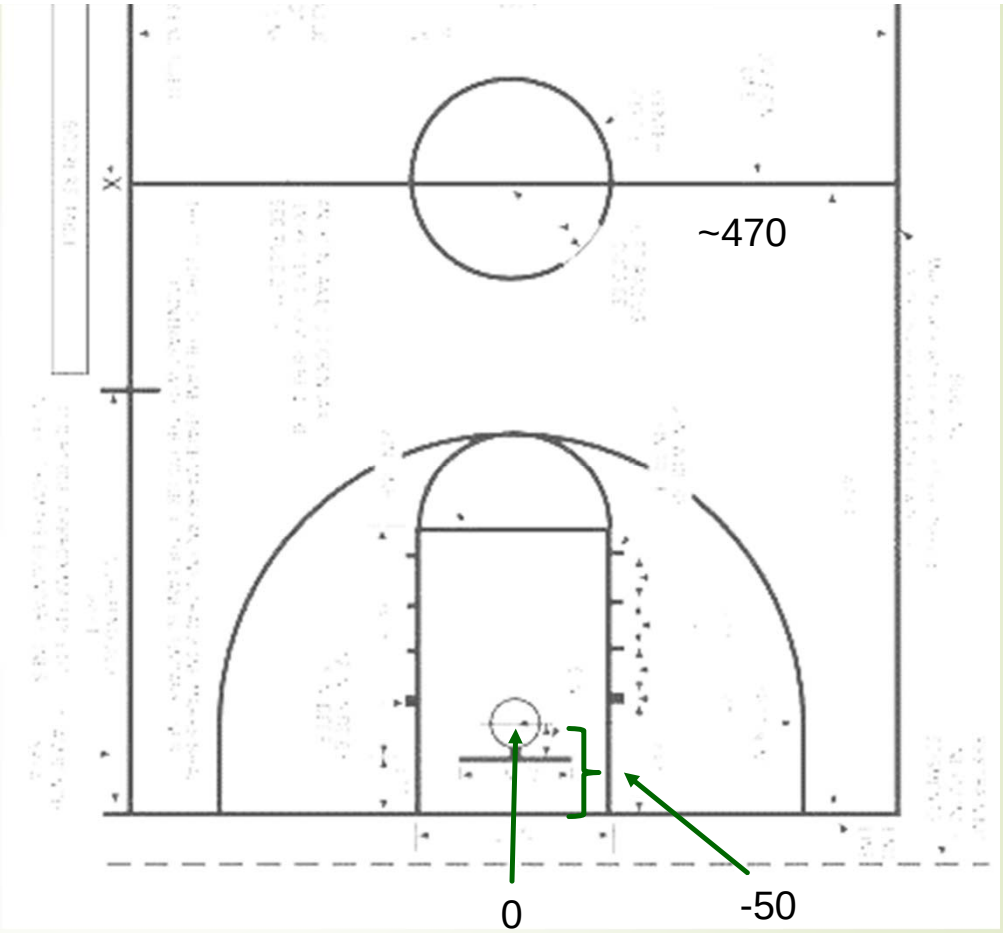
- You will have to change the "set working directory" in kobeinit.R to the location of your files.
- There is a function call commented out in kobeinit.R, check_pkgs(), that will check and install packages. It does ask first. You can source kobe_func.R first, then run check_pkgs() before getting started.
- Also, I have only run this on the windows version of R. Other than the directory name in setwd, should work under Linux.

Operation:

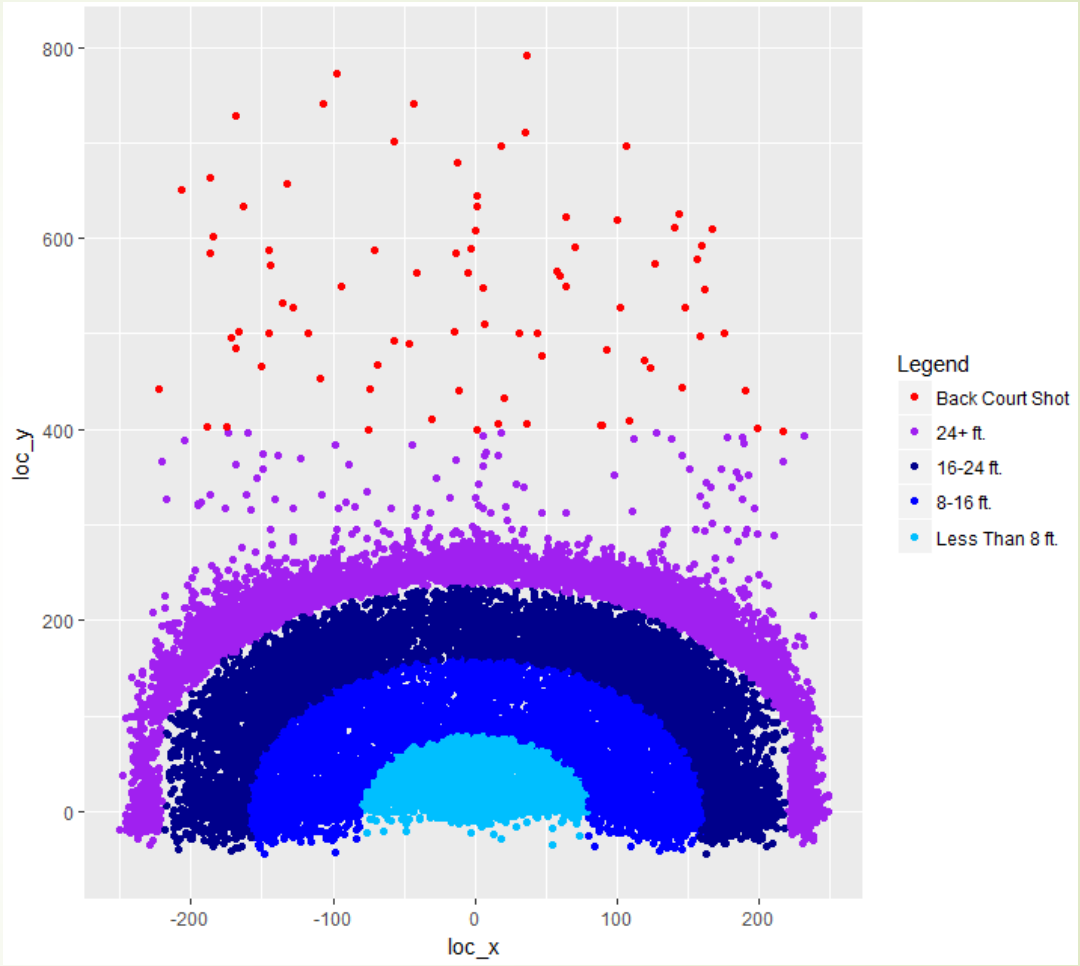
1. Source kobeinit.R to initialize the data frames
2. You can then source kobe_explore.R to generate all plots or select a set to run (ctrl+return). I usually use the x11() device, but you can also use the PDF code.
3. And/or you can run any of the models. Some of the data and plots are sent to files for future reference

# Basket Ball Court Dimensions

Scale: 1 ~ 0.1 ft

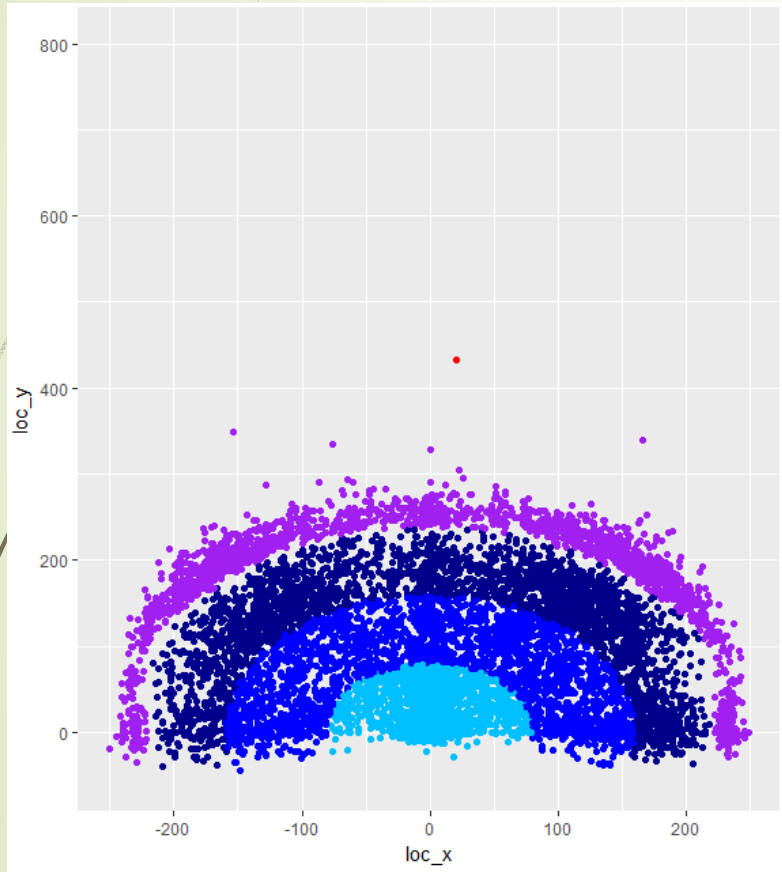


# Shot by distance zone
# All Shots, including test set

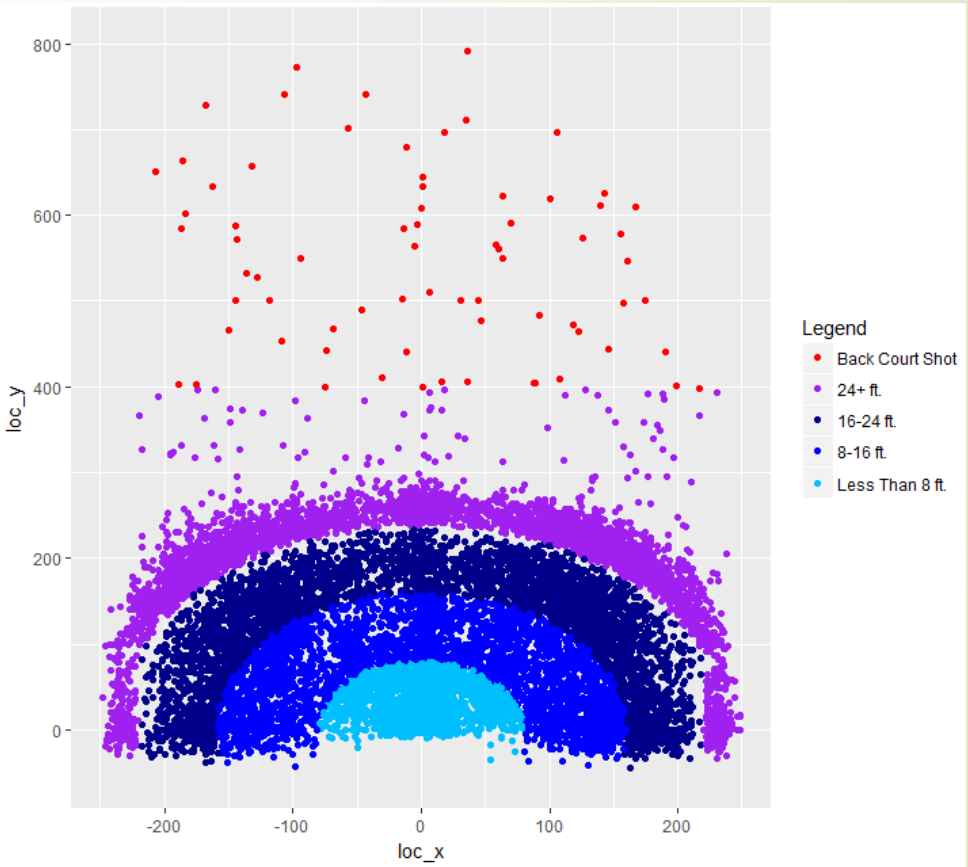


# Shot by distance zone made, not made

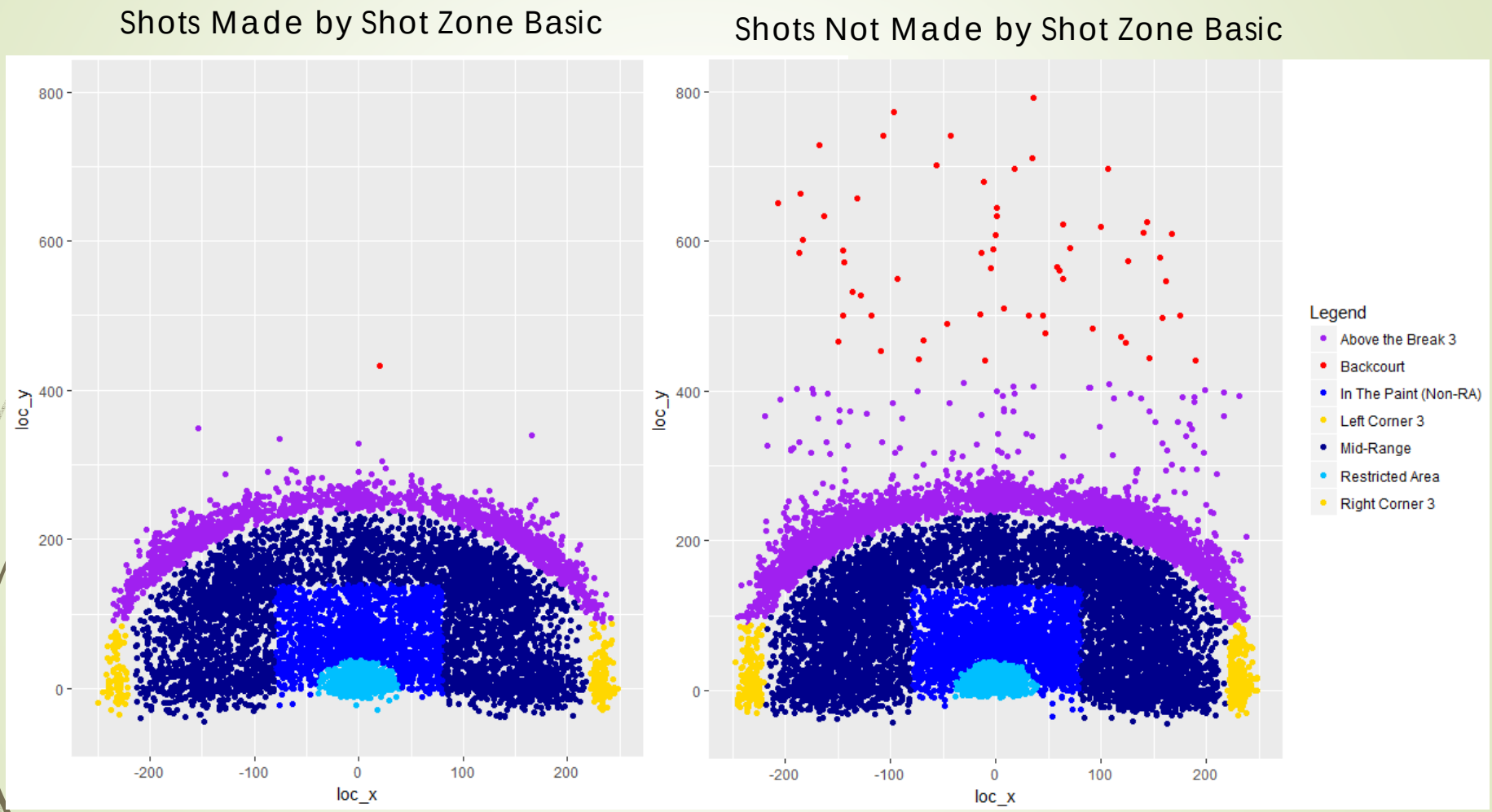
Shots Made



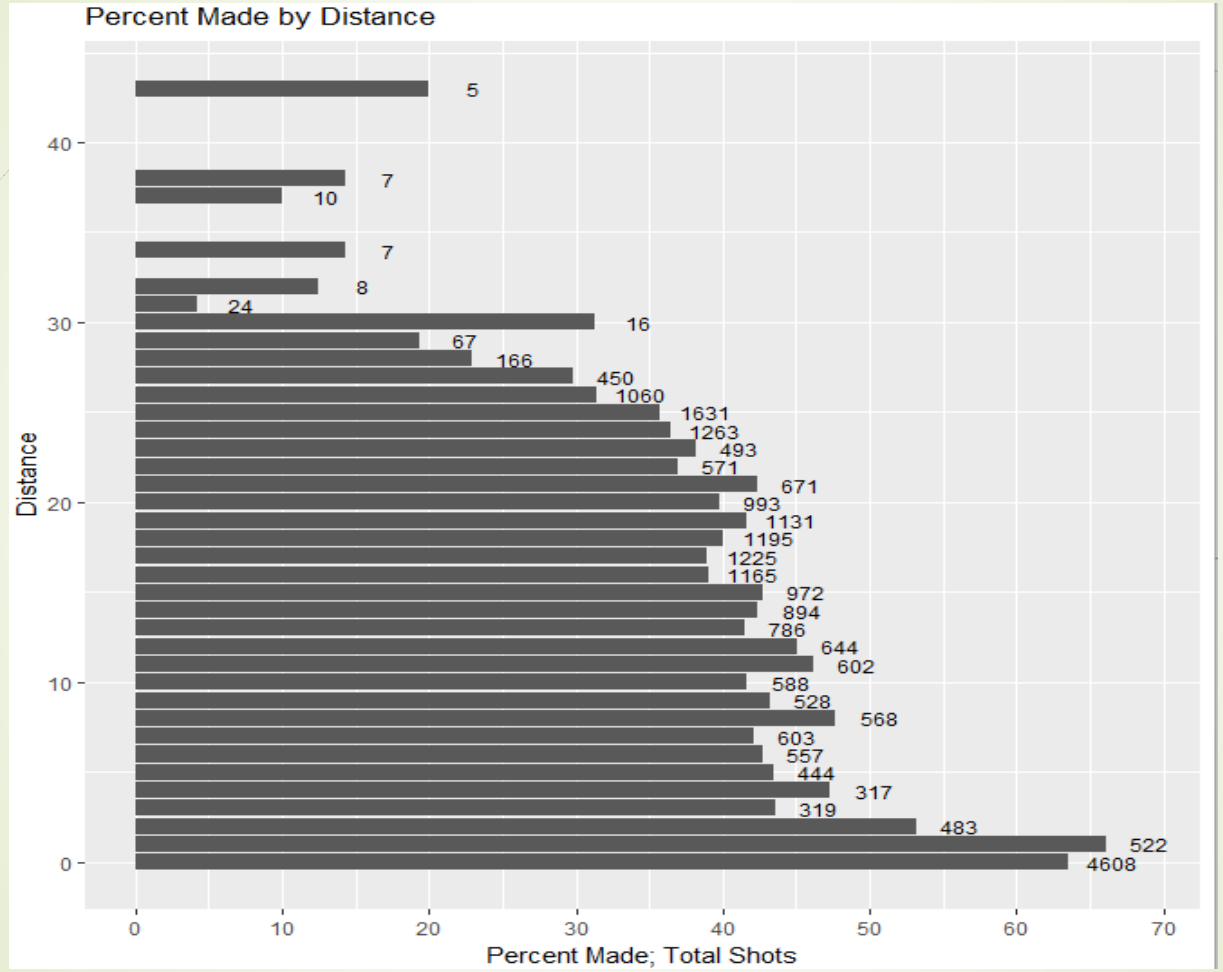

Shots Not Made



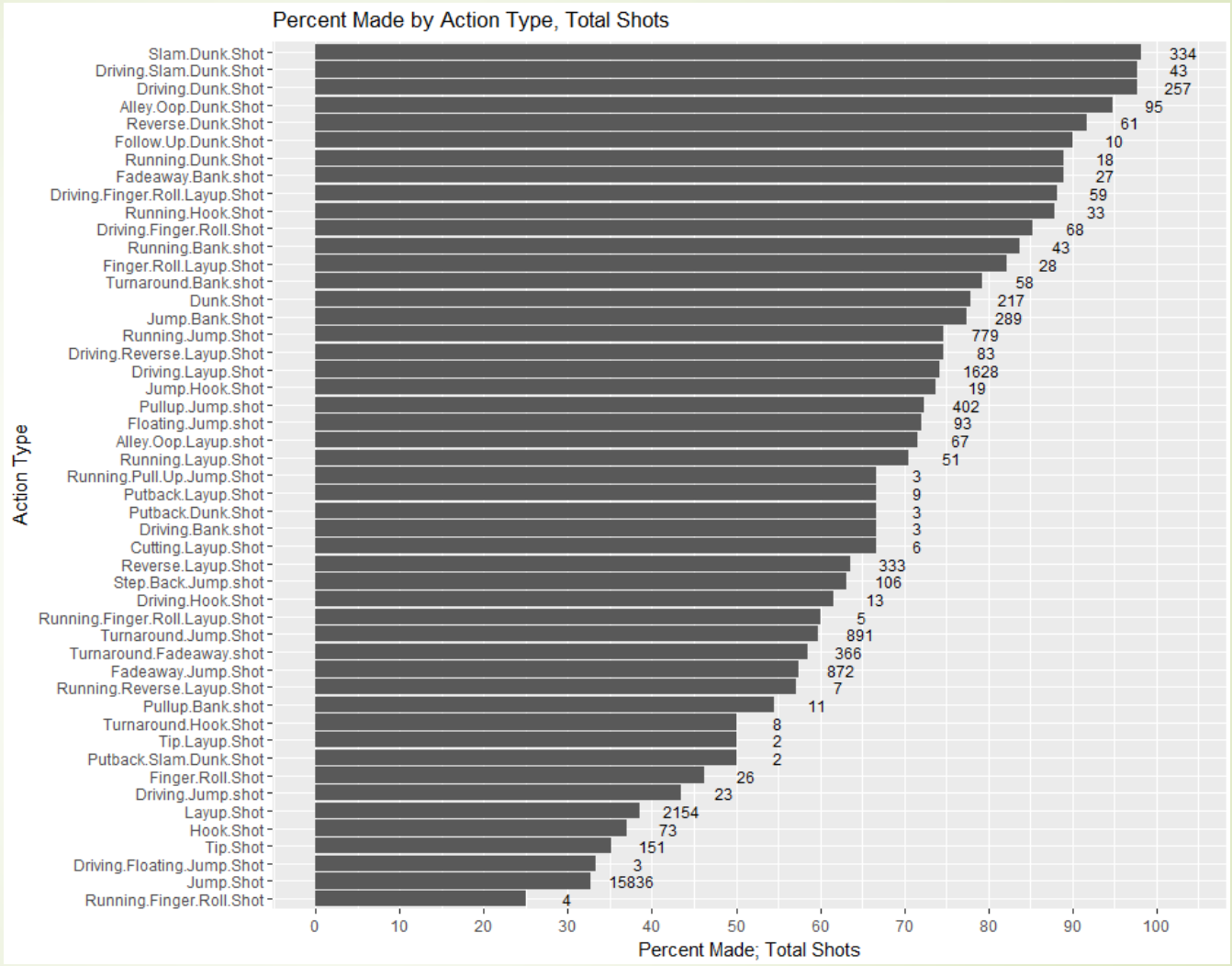
# Shots by "shot zone basic"



# Shots by Distance, Percent Made



# Action Type


Percent Made by Action Type, Total Shots
Action Type
Slam.Dunk.Shot 334
Driving.Slam.Dunk.Shot 43
Driving.Dunk.Shot 257
Alley.Oop.Dunk.Shot 95
Reverse.Dunk.Shot 61
Follow.Up.Dunk.Shot 10
Running.Dunk.Shot 18
Fadeaway.Bank.shot 27
Driving.Finger.Roll.Layup.Shot 59
Running.Hook.Shot 33
Driving.Finger.Roll.Shot 68
Running.Bank.shot 43
Finger.Roll.Layup.Shot 28
Turnaround.Bank.shot 58
Dunk.Shot 217
Jump.Bank.Shot 289
Running.Jump.Shot 779
Driving.Reverse.Layup.Shot 83
Driving.Layup.Shot 1628
Jump.Hook.Shot 19
Pullup.Jump.shot 402
Floating.Jump.shot 93
Alley.Oop.Layup.shot 67
Running.Layup.Shot 51
Running.Pull.Up.Jump.Shot 3
Putback.Layup.Shot 9
Putback.Dunk.Shot 3
Driving.Bank.shot 3
Cutting.Layup.Shot 6
Reverse.Layup.Shot 333
Step.Back.Jump.shot 106
Driving.Hook.Shot 13
Running.Finger.Roll.Layup.Shot 5
Turnaround.Jump.Shot 891
Turnaround.Fadeaway.shot 366
Fadeaway.Jump.Shot 872
Running.Reverse.Layup.Shot 7
Pullup.Bank.shot 11
Turnaround.Hook.Shot 8
Tip.Layup.Shot 2
Putback.Slam.Dunk.Shot 2
Finger.Roll.Shot 26
Driving.Jump.shot 23
Layup.Shot 2154
Hook.Shot 73
Tip.Shot 151
Driving.Floating.Jump.Shot 3
Jump.Shot 15836
Running.Finger.Roll.Shot 4
0 10 20 30 40 50 60 70 80 90 100
Percent Made; Total Shots

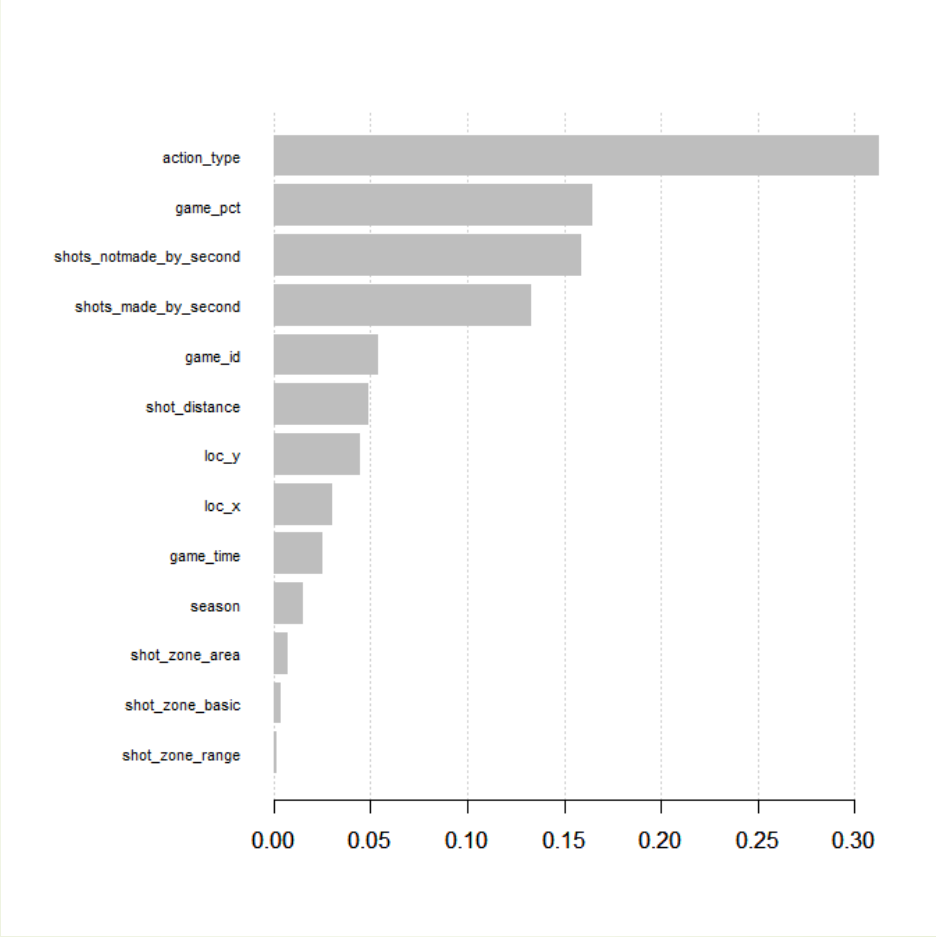
# Action_type at 0 distance

| | action_type | made |
|---|---|---|
| 8 | Driving.Layup.Shot | 1006 |
| 17 | Layup.Shot | 613 |
| 31 | Slam.Dunk.Shot | 309 |
| 4 | Driving.Dunk.Shot | 222 |
| 22 | Reverse.Layup.Shot | 177 |
| 11 | Dunk.Shot | 151 |
| 1 | Alley.Oop.Dunk.Shot | 78 |
| 21 | Reverse.Dunk.Shot | 54 |
| 6 | Driving.Finger.Roll.Shot | 49 |
| 32 | Tip.Shot | 42 |
| 2 | Alley.Oop.Layup.shot | 40 |
| 5 | Driving.Finger.Roll.Layup.Shot | 35 |
| 9 | Driving.Reverse.Layup.Shot | 28 |
| 10 | Driving.Slam.Dunk.Shot | 27 |
| 29 | Running.Layup.Shot | 25 |
| 24 | Running.Dunk.Shot | 14 |

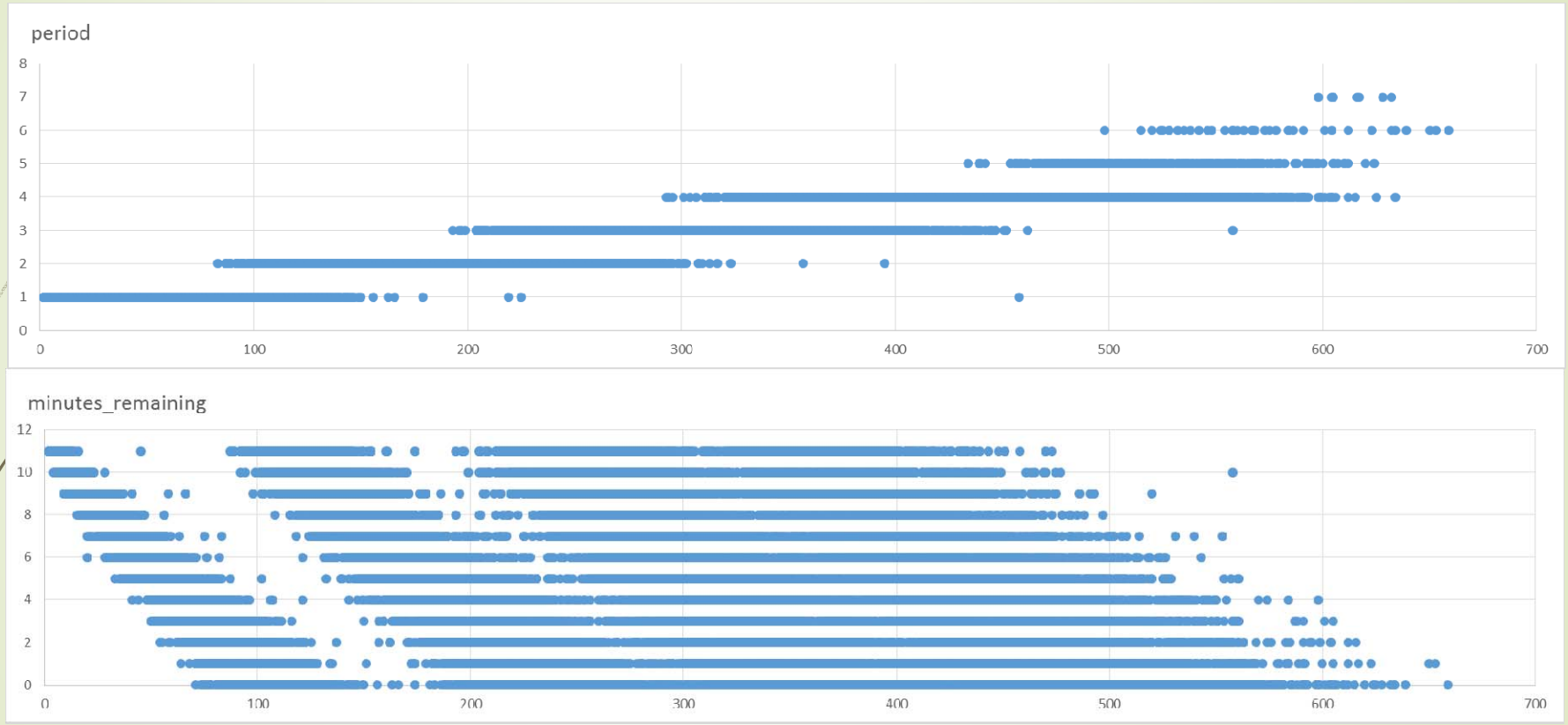
Filter

| | action_type | not_made |
|---|---|---|
| 16 | Layup.Shot | 1034 |
| 7 | Driving.Layup.Shot | 336 |
| 21 | Reverse.Layup.Shot | 89 |
| 30 | Tip.Shot | 85 |
| 10 | Dunk.Shot | 43 |
| 2 | Alley.Oop.Layup.shot | 13 |

# XGBoost importance plot



# Game_event_id



# Useful links

- xgboost
  - Paper: XGBoost: A Scalable Tree Boosting System
    - https://arxiv.org/pdf/1603.02754.pdf
  - Video
    - https://youtu.be/ufHo8vbk6g4
      - detailed but a bit slow, more on parameters

# R Links

- **Google/Stack overflow search (find most of my questions answered here)**
- https://www.r-bloggers.com/
  - R specific info/blogs
- https://shiny.rstudio.com/gallery/
  - Examples of a web server "shiny" tool specific to R
- http://www.r-graph-gallery.com/all-graphs/
  - Example Graphs/visualization
- https://www.udemy.com/machinelearning/learn/v4/overview
- Kirill Eremenko instructor. Python and R examples for each topic
- https://www.coursera.org/specializations/jhu-data-science
  - Great data science series. Jeff Leek in particular was great.
  - www.coursera.org/jhu (free version)