SEI x Phillies Hackathon 2024

Villanova Sports Analytics Club

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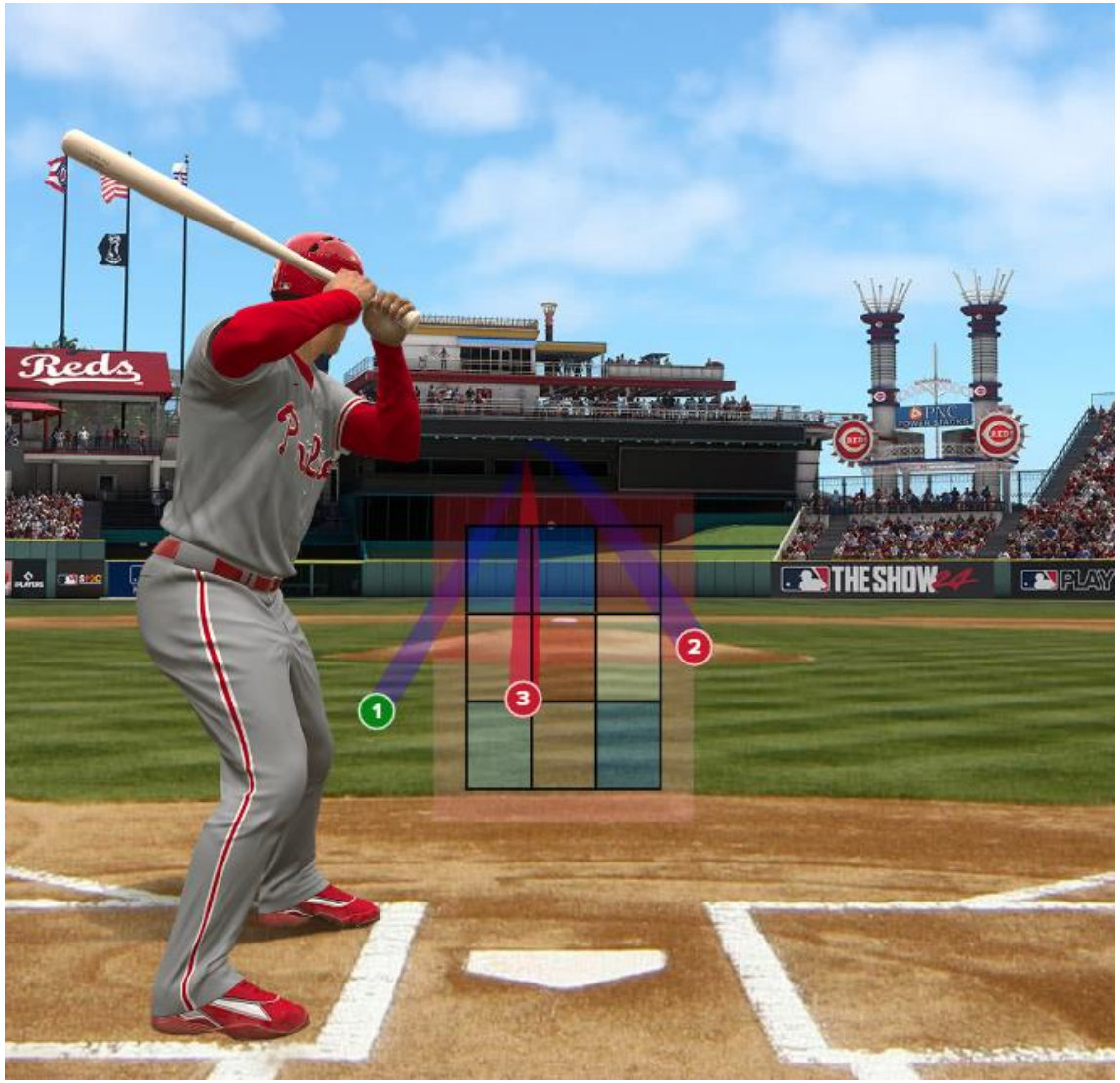
Problem/Prompt

- Develop a model to estimate the probability that a taken pitch will be called a strike

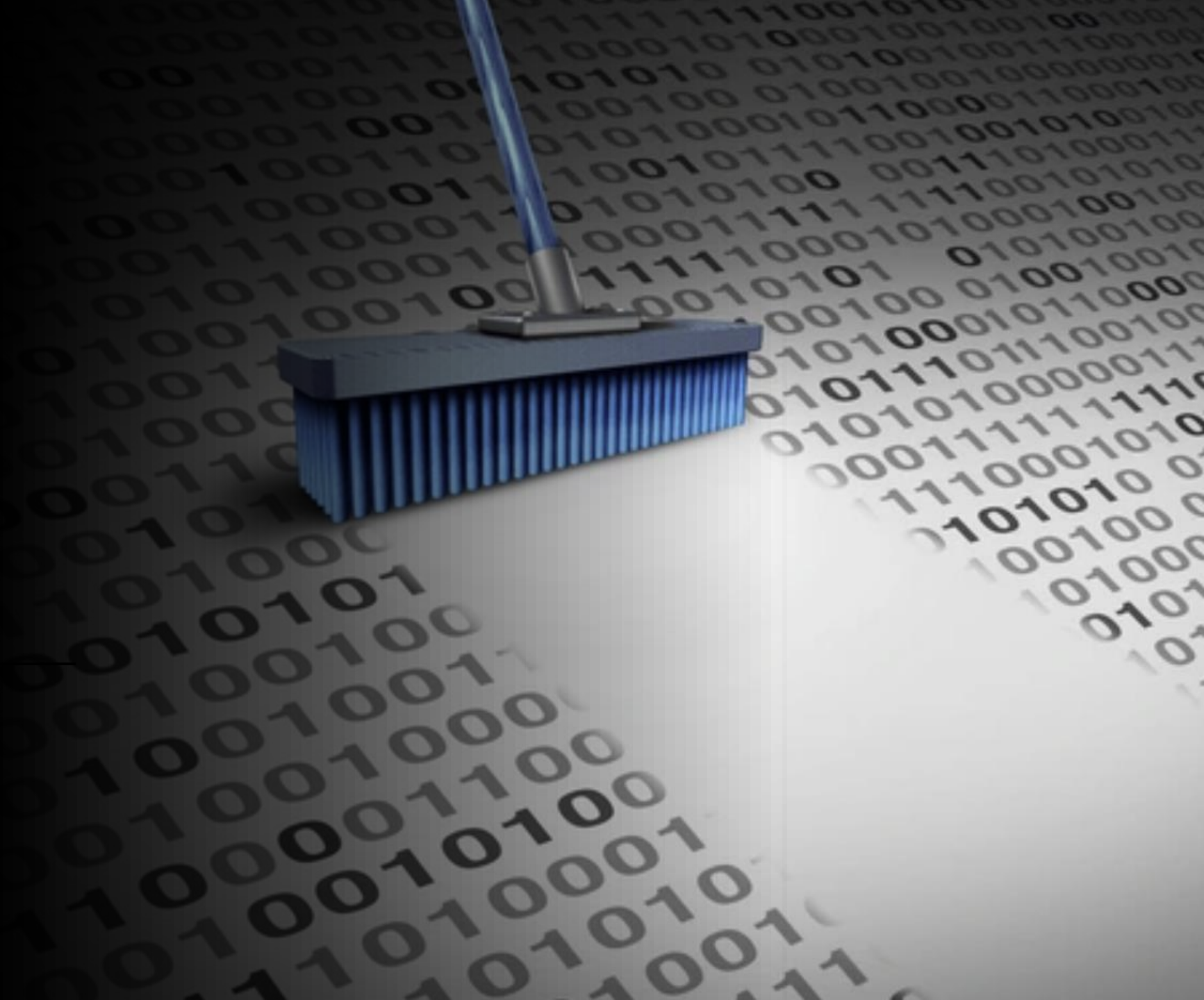
- Using strike probability model, develop a product to display predicted called strike probabilities



Objective/Early Thoughts

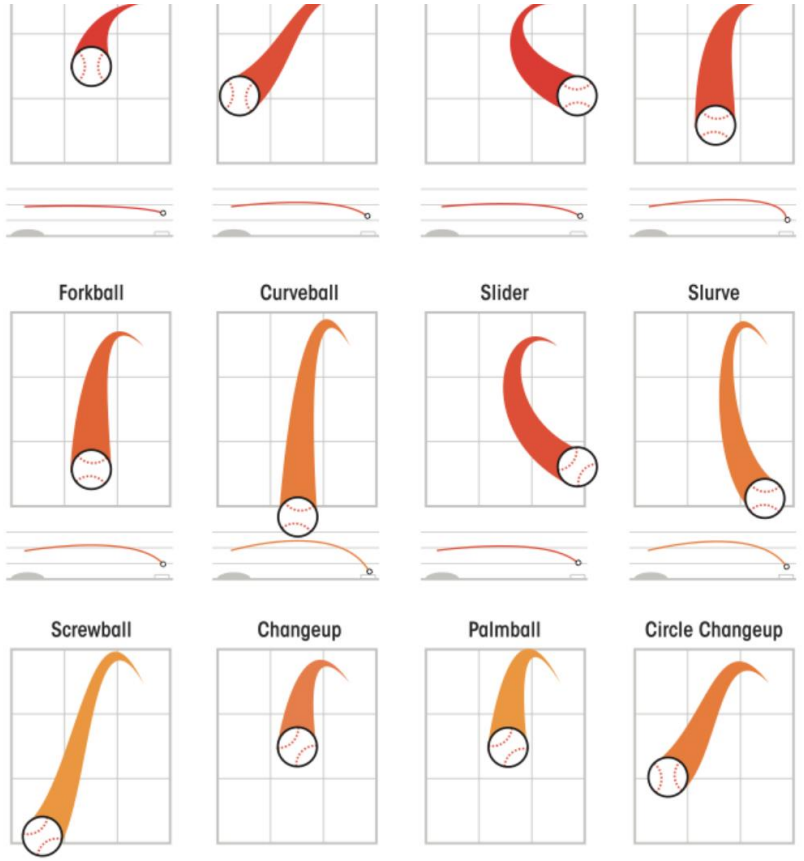
- Given pitch-by-pitch data from the 2022 MLB Season
- First objective was to model the probability that a pitch would be called a strike based on location, type of pitch, the pitch's releases speed, and game situation (count, number of outs, inning)
- Building out initial model to include various factors, such as catcher framing and umpire tendencies to make accurate adjustments

Data Processing & Cleaning



Current Data

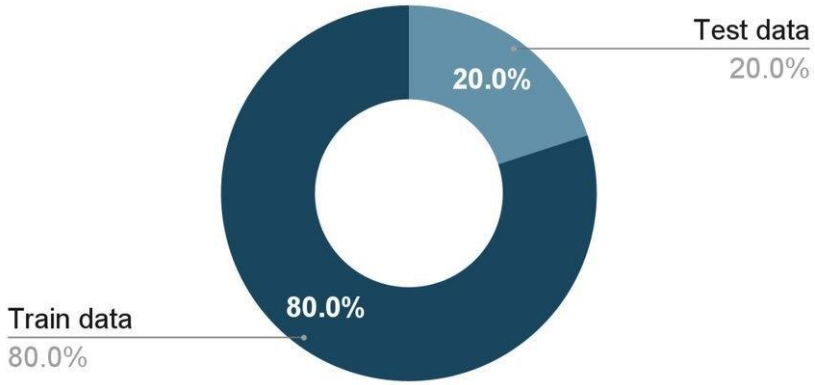
- Filtered necessary columns of data from dataset (ex. IDs of the pitcher, batter, catcher, pitch result, 3D coordinates of the pitch)
- Created new variables to improve model's predictive power (ex. distance of each pitch from top and bottom of strike zone)
- Converted categorical/character-defined variables into binary representations (ex. delineate fastball vs breaking ball vs off-speed)



Additional Data

- Appended catcher and umpire data (ex. games played, umpire accuracy) for small sample baselines

- Divided data into two parts: 80% into training partition and 20% into testing partition



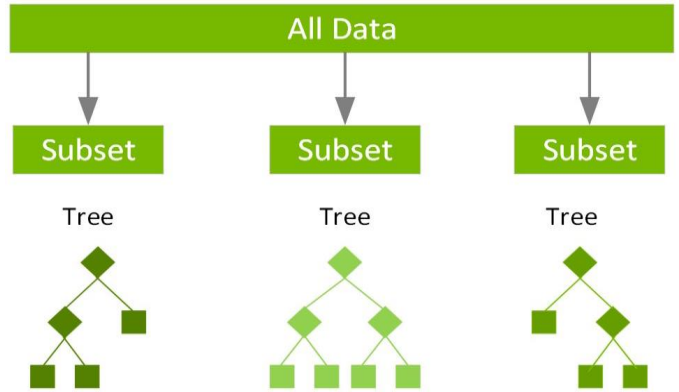
Additional Data Sourcing

- Baseball Savant pitch data from 2022 and 2021 to help create a predictive number for catcher framing
- Player ID data set to pair IDs with player names from Smart Fantasy Baseball
- 2022 Umpire Data from Umpire Scorecards to gather each umpire's mean accuracy

Modeling

Methodology

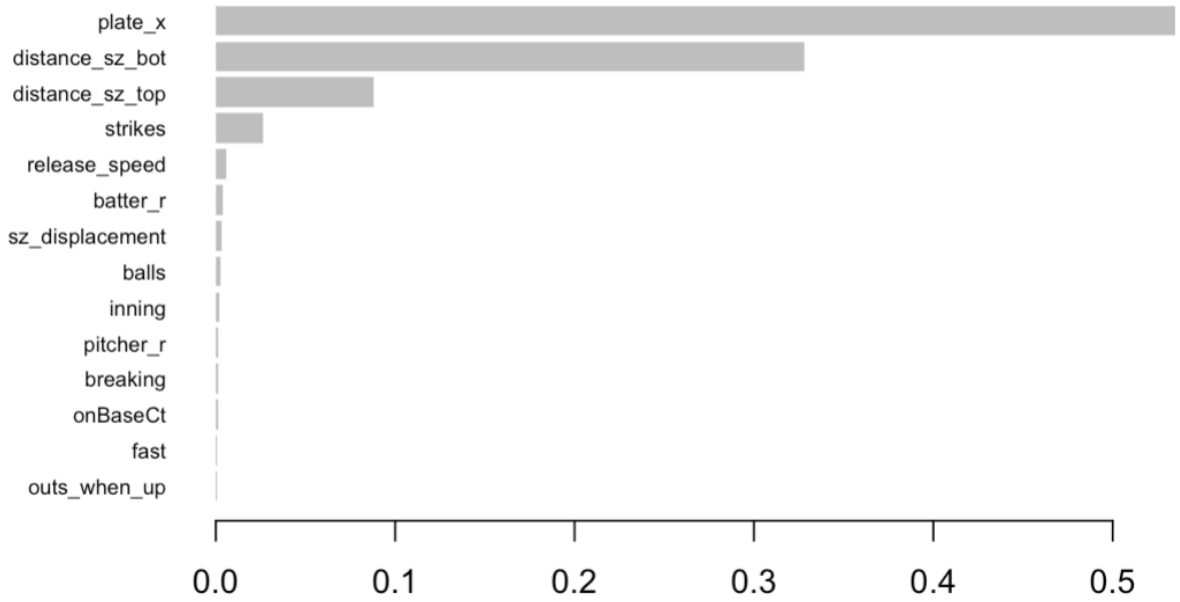
- Used XGBoost Model in R to model probability of a pitch being called a strike
  - Powerful machine learning algorithm used for regression that builds a strong predictive model through decision trees
  - Decision trees take in all relevant data and predict whether the pitch will be a strike or not
  - Initially, the model makes mistakes, but each next decision tree learns from the previous one, and becomes a little more accurate each iteration at predicting whether the pitch was a strike or not
  - This process is repeated until the model minimizes what is known as a "log loss" function, lower "log loss" indicates that the model is very accurate



Details: Initial Model

- **Target Value:** Strike Probability

- Initial XGBoost Model had the following factors:
  - Horizontal location of the pitch
  - Vertical distance from top/bottom of hitter's median strike zone
  - # of balls/strikes prior to pitch
  - Handedness of batter/pitcher
  - Pitch type and velocity
  - Game state (inning, runners on base, outs)



Details: Improvements

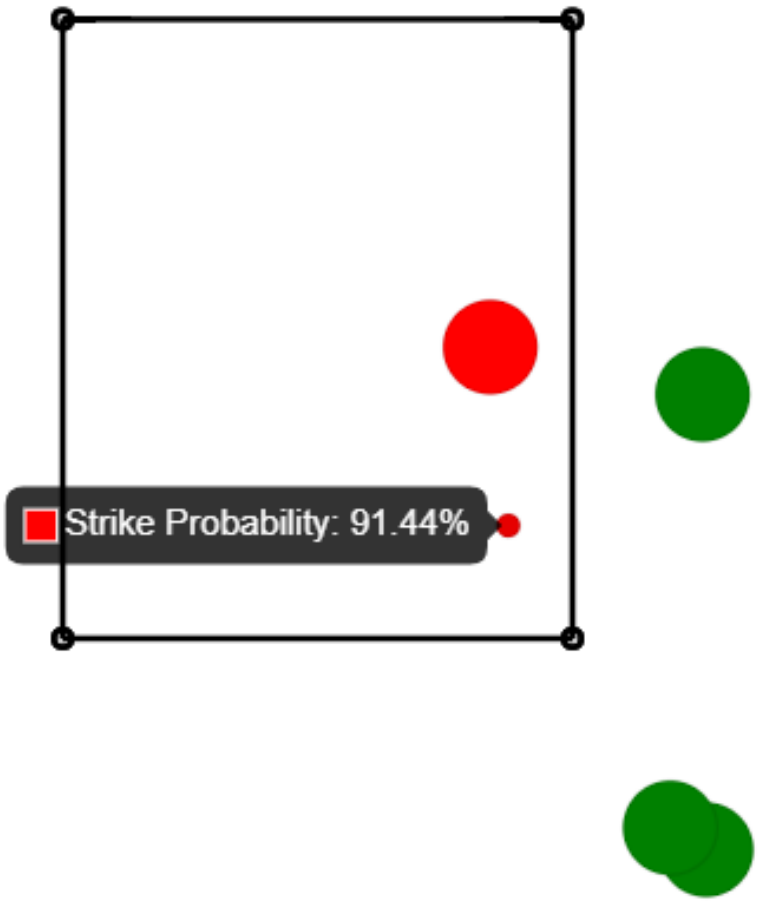
- Used initial model to create catcher framing statistic
  - Used relationship between expected and actual strikes to determine positive framing impact
- Final model factors:
  - All initial model factors
  - Catcher Framing
  - Umpire Accuracy
- Final model had a test set accuracy of about 93% and an AUC of .9818

	PLAYERNAME	StkAx
1	Jose Trevino	146.35792
2	Jonah Heim	122.79662
3	Max Stassi	119.99834
4	J.T. Realmuto	119.97990
5	Jonah Heim	102.43092
6	Tucker Barnhart	99.39381
7	Mike Zunino	94.62138
8	Sean Murphy	84.46384
9	Cal Raleigh	82.32321
10	Omar Narvaez	78.70770

Applications

Strike Probability Visualization

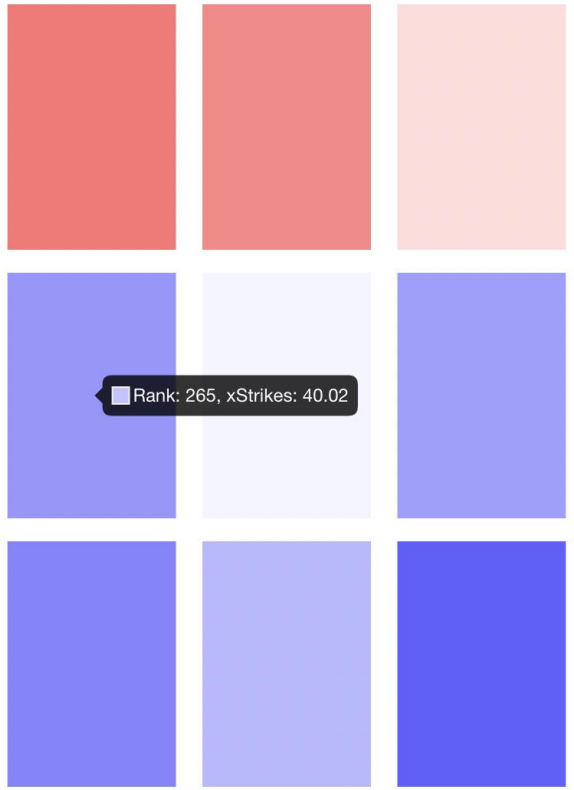
- User chooses Pitcher, Game Date, Batter information and receives a graphic that displays the hitter's personalized strike zone, called strikes (red), called balls (green)
- Hovering over any of the pitches produces the strike probability based on our model
- Clicking on a pitch opens a link to the video of the pitch being thrown

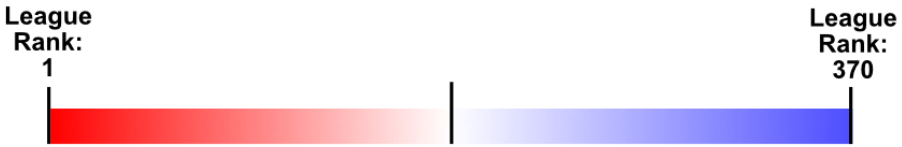


[Website Link]

Batter xStrikes Heatmap

- User chooses Batter and receives a heatmap that breaks that batter's pitches faced into 9 zones
- Also outputs league rank based on Expected Strikes
- The lower the rank the fewer expected strikes in that zone





[Website Link]

Specific Applications

Batters

- Insight into a hitter's swing decisions
- Use expected strikes to adjust swing decisions based on strike probability trends broken up by zone

Pitchers

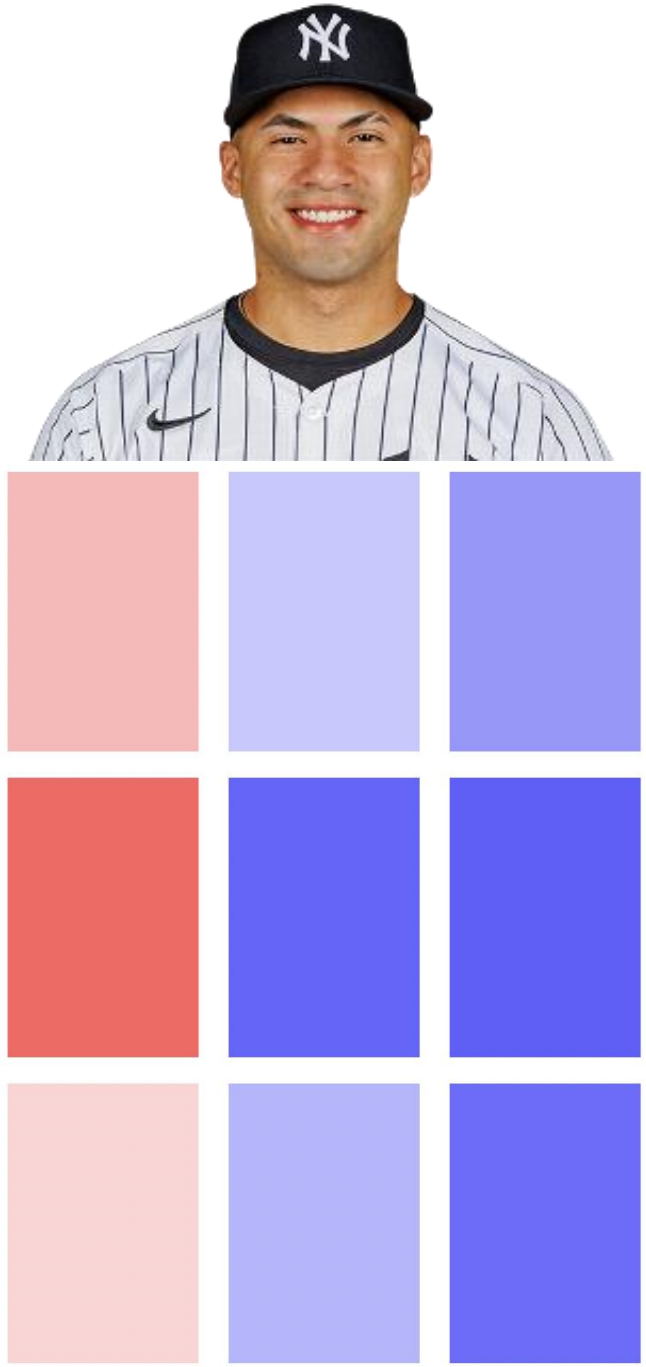
- Can help improve what type of pitch to throw in certain situations
- Can improve location decisions based on batters faced

Example

Key: Players with imbalanced zones

Gleyber Torres

- 82nd in xStrks for the middle inside pitch (middle left quadrant)
- 350th for the middle away pitch (middle right quadrant)
- 245th for middle middle pitch (middle center quadrant)



Possible Improvements

- Use a larger sample of pitches from other seasons for training the model
- Having minor league data to better evaluate catcher framing for young/low MLB sample catchers
- Breaking out umpire call tendencies into different zones
- Evaluating pitch movement to see if it has meaningful impact on strike probability

Main Takeaways

- XGBoost Model to predict strike probability
- Most significant variables are vertical and horizontal pitch location
- # of strikes in count = next most important factor
- Display the results of model through heatmap & plots
- Our model and website together can provide insights towards catcher/umpire performance & help batters/pitchers make smarter decisions

Appendix

Model Parameters

```r
#parameters for the XGBoost model
params <- list(
  booster = "gbtree",
  objective = "binary:logistic",
  eta = 0.3,
  gamma = 0,
  max_depth = 3,
  min_child_weight = 1,
  subsample = 0.6,
  colsample_bytree = 0.6
)

#training the model
xgb_model <- xgb.train(params = params, data = dtrain, nrounds = 40,
                       watchlist = list(eval = dtest, train = dtrain),
                       early_stopping_rounds = 10)
```

Databases Utilized

```
```{r}
df <- read.csv("k_prob.csv")
df_detail <- read.csv("All_2022_Pitches.csv")
df_detail_2021 <- read.csv("All_2021_Pitches.csv")
catcher_info <- read.csv("SFBB_Player_ID_Map.csv")
ump_data <- read.csv("2022_Umpire.csv")
```
```

Libraries Utilized

```r
library(tidyverse)
library(readr)
library(caret)
library(xgboost)
library(ROCR)
library(lubridate)
library(Lahman)
library(dplyr)
```