

The background of the slide is a photograph of a baseball stadium during sunset. The sky is a warm orange and red. The stadium lights are on, and the stands are filled with spectators. A large digital scoreboard is visible in the upper right corner.

STATS 601

# Caught Looking: Analyzing Variations in Umpire Strike Zones

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A photograph of a baseball coach in a dark polo shirt and cap pointing his finger at a player's chin, while the player looks off to the side.

MOTIVATION

# Motivation

## Problem Setting

In baseball, the home plate umpire is tasked with calling every pitch a ball or strike, unless the batter swings

MLB provides PITCHf/x data which includes information about every pitch such as location, umpire's call, speed, game situation, etc.[3]

We want to use this data to see how close umpires come to calling the true strike zone

The Strike Zone

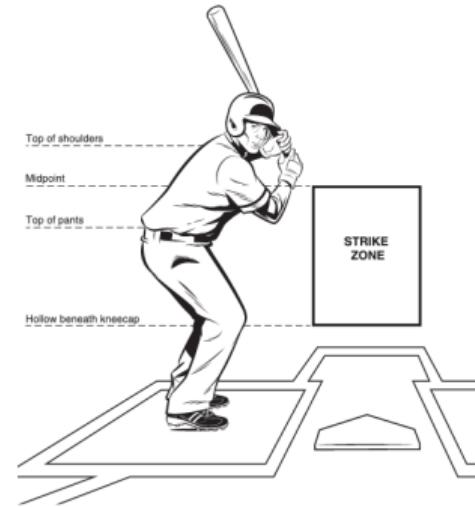


Figure: Official MLB strike zone[2]

# Motivation

A brief detour into the rules of baseball

- If a batter gets 3 strikes before 4 balls, he is out. Otherwise he gets to walk to first base
- Therefore, the ball/strike call is more consequential in certain situations, leading umpires to possibly expand or shrink their strike zones

AT BAT	37	BALL	1	STRIKE	2	OUT	1	H E	3					
GAMES		1	2	3	4	5	6	7	8	9	10	RUNS	HITS	ERR
GUEST	103	10	12	00						8	9	1		
HOME	022	11	12	0						9	12	1		

**Our primary question is whether different umpires have different strike zones in counts with [0, 1] strikes, 2 strikes, [0, 2] balls, 3 balls. We consider umpires with at least 30 games behind the plate in 2018.**

# Motivation

## Actionable items

- Evaluating umpire ability to determine who gets promotions, playoff assignments, etc.
- Assessing the need for automatic strike zone calls/robot umpires
- Delivering insights to pitchers and batters



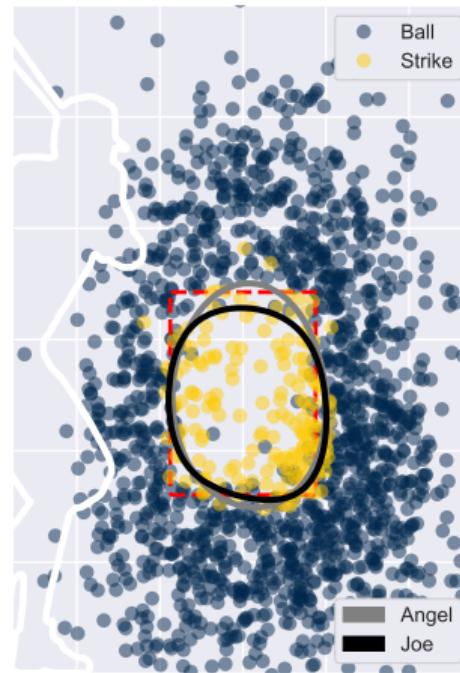
**This is a problem of interest to league officials, teams, and fans alike**

# Motivation

## Quantifying Differences in Strike Zones

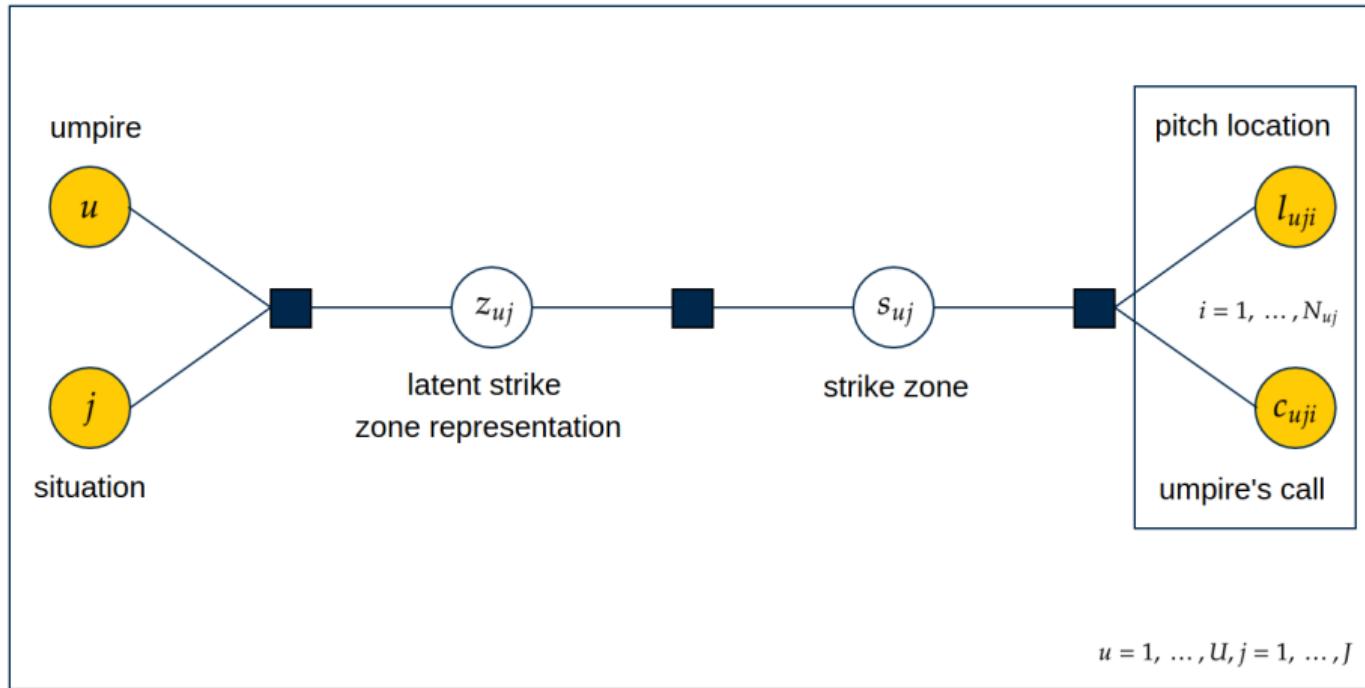
The plot on the right shows that Angel Hernandez and Joe West have different strike zones in counts with 2 strikes and <3 balls, but we need to develop a method to quantify the difference

Angel Hernandez vs. Joe West Strike Zone



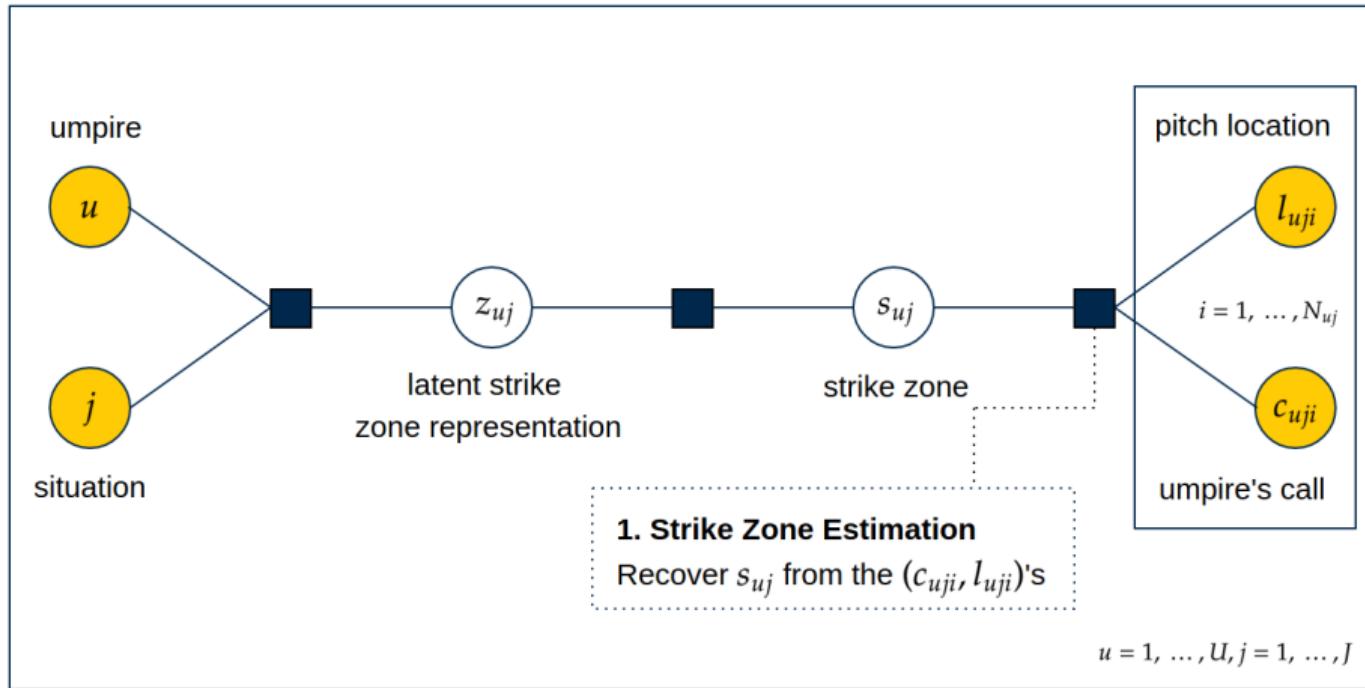
# Motivation

A graphical depiction of our problem



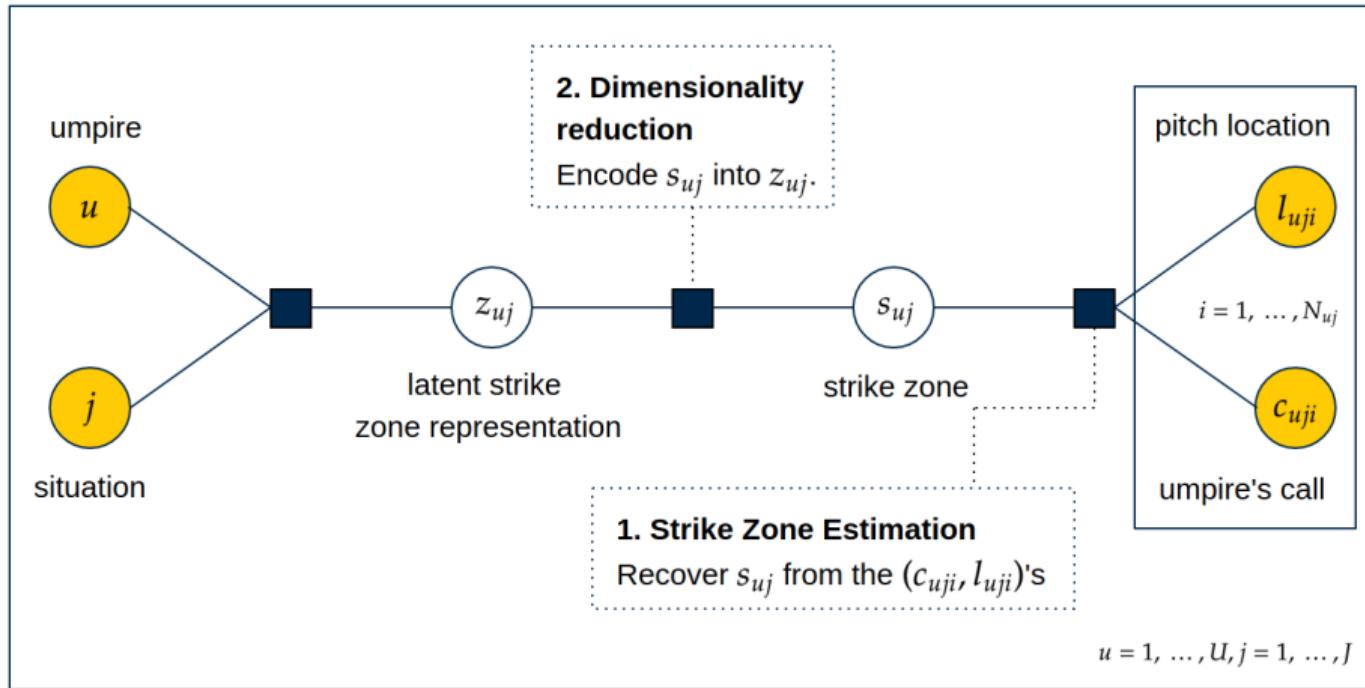
# Motivation

A graphical depiction of our problem



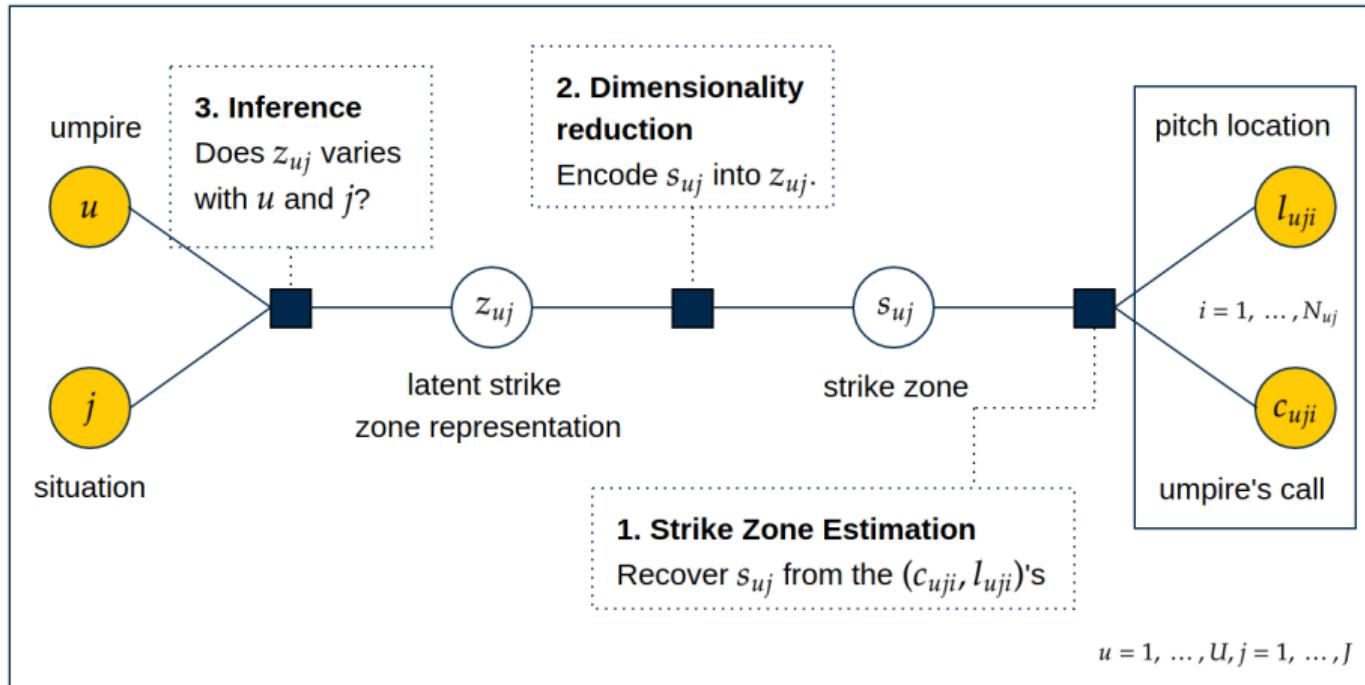
# Motivation

A graphical depiction of our problem



# Motivation

A graphical depiction of our problem



A professional baseball player with long blonde hair and a beard, wearing a blue New York Mets uniform and cap, stands in profile facing right. He is holding a baseball in his left hand. The background is blurred green foliage.

# CLASSIFICATION

# Classification

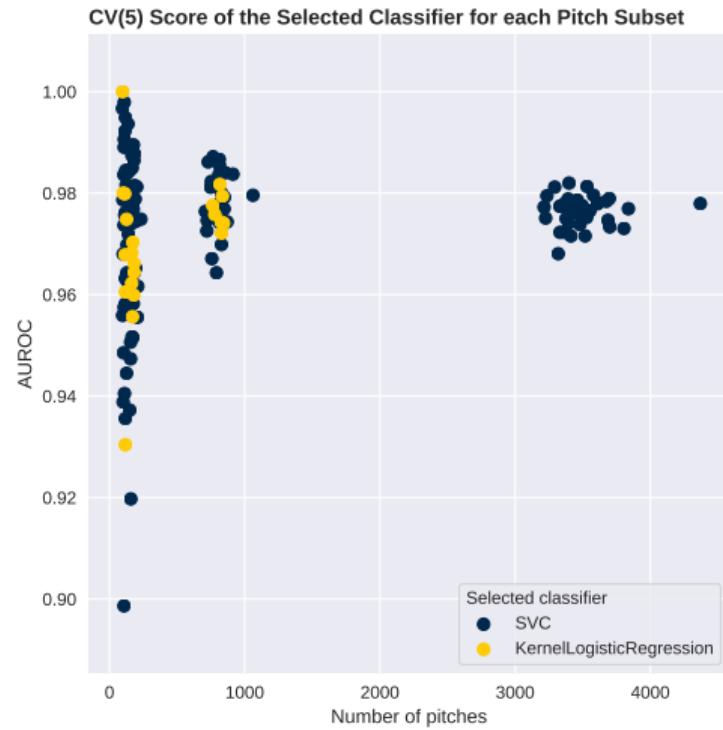
Choosing a model to learn each umpire's strike zone

- We want to learn the strike zone boundary for each umpire in a variety of game situations
- Challenge is finding good boundary for specific game situations, where sample size may be small, without overfitting
- Some methods we tried included
  - **Kernel Logistic regression**
  - Logistic GAM
  - Neural network
  - **Kernel SVM**
  - Tree-based methods (AdaBoost, CART, Random Forest, Gradient Boosting)

# Classification

## Cross validation results

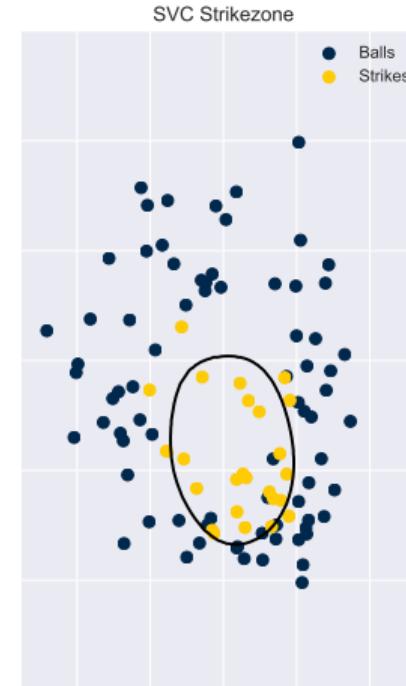
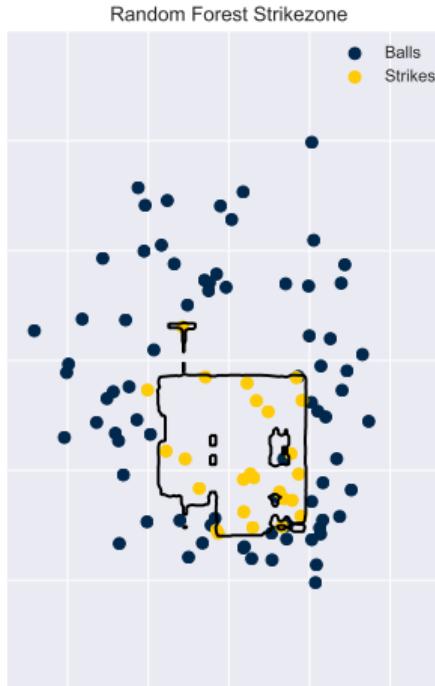
As some umpire/situation combinations have small sample size, we use cross validation to determine the best classifier (and tune them) for each subsample of the data  
We use the AUROC score since it is less sensitive to unbalanced classes.



# Classification

## Comparison of Kernel and Ensemble methods

Although these methods have similar error rates, SVC produces a more realistic boundary

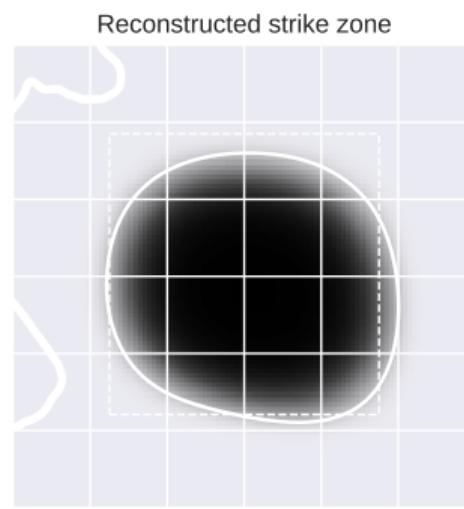
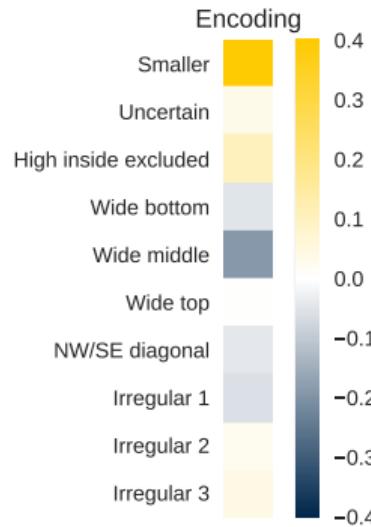
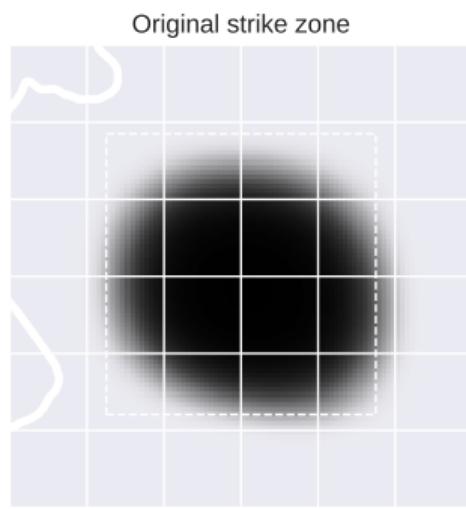




# DIMENSIONALITY REDUCTION

# Dimensionality Reduction

## Encoding



# Dimensionality Reduction

Model and number of components selection

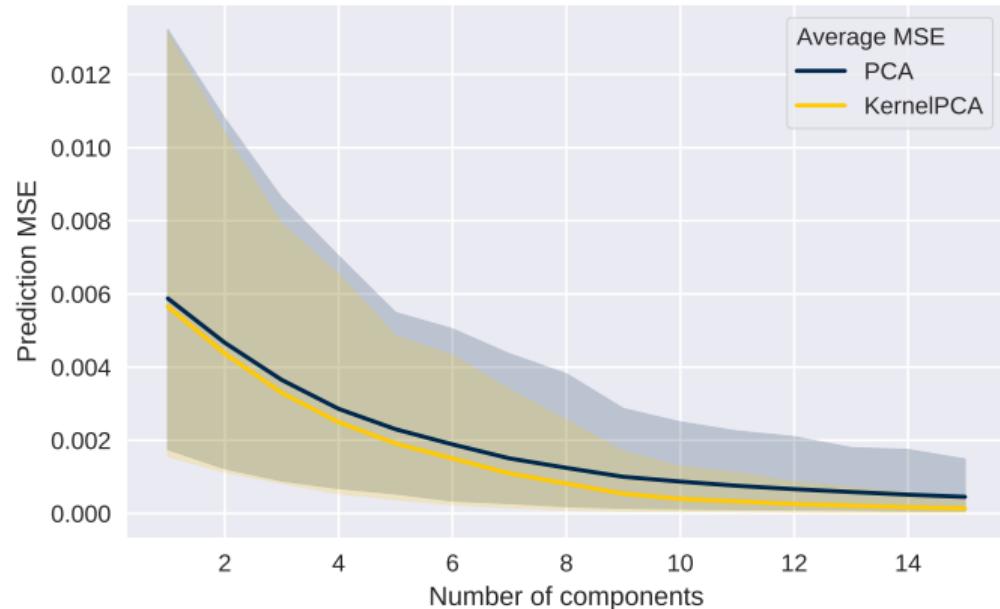
## PCA and Kernel PCA

- **orthogonal** embeddings are desirable for inference

## CNN Autoencoder

- Natural choice for image encoding
- Similar prediction error
- **non-orthogonal** embeddings

Encoders' Prediction Error by Number of Components



# Dimensionality Reduction

## Component interpretation

Component	Interpretation	
1	Overall size	
2	Overall uncertainty	
3	High inside	
4	Lower width	
5	Middle width	
6	Upper width	
7	Diagonal direction	Visualization app
8	Irregular shape 1	
9	Irregular shape 2	
10	Irregular shape 3	

A photograph of four Major League Baseball umpires standing on a field at night. They are all wearing black shirts with the MLB logo and grey pants. The umpire on the far left has his hands on his hips. The second from the left has his hand near his mouth, possibly blowing a whistle. The third has his hand on his chest and is holding a black helmet. The fourth has his hands clasped in front of him.

# INFERENCE

# Inference

## Multivariate Analysis of Variance

Model : components ~ umpire + ball count \* strike count

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### MANOVA results

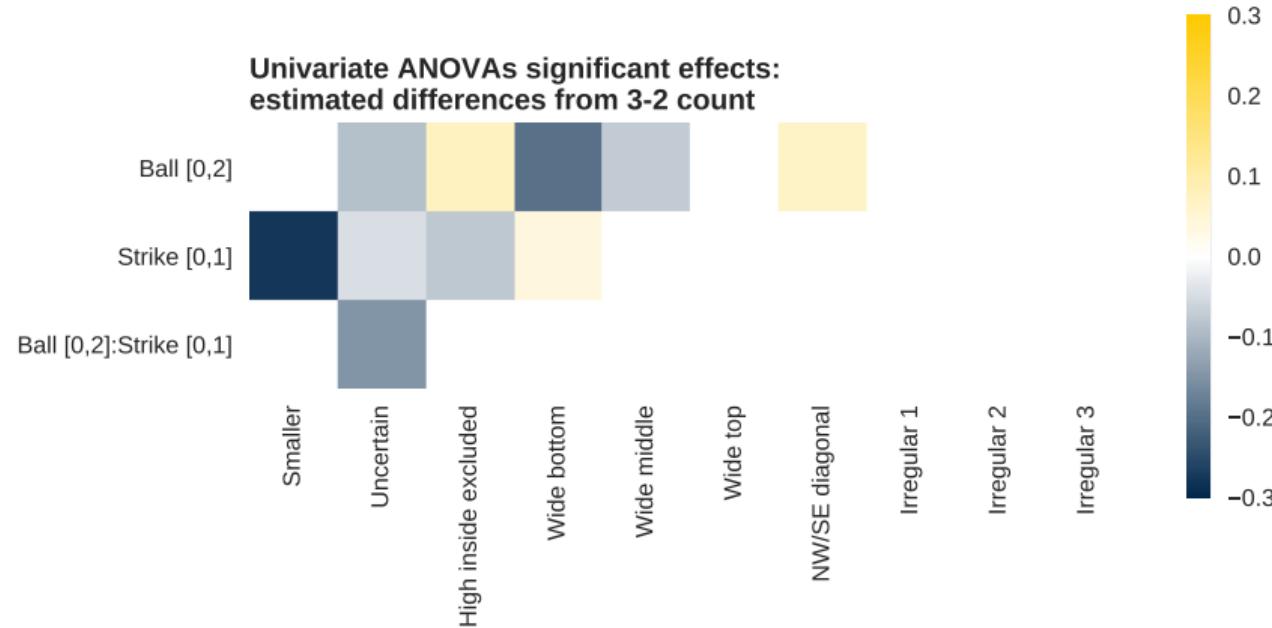
Term	Wilks' Lambda	Num. df	Den. df	F value	p-value
Umpire	0.0142	380	1046	1.51813	1.80e-07
Ball count	0.4112	10	105	15.0334	2.65e-16
Strike count	0.3534	10	105	19.0555	1.74e-19
Ball count:Strike count	0.7675	10	105	3.1805	0.0013

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# Inference

## Univariate Analyses of Variance

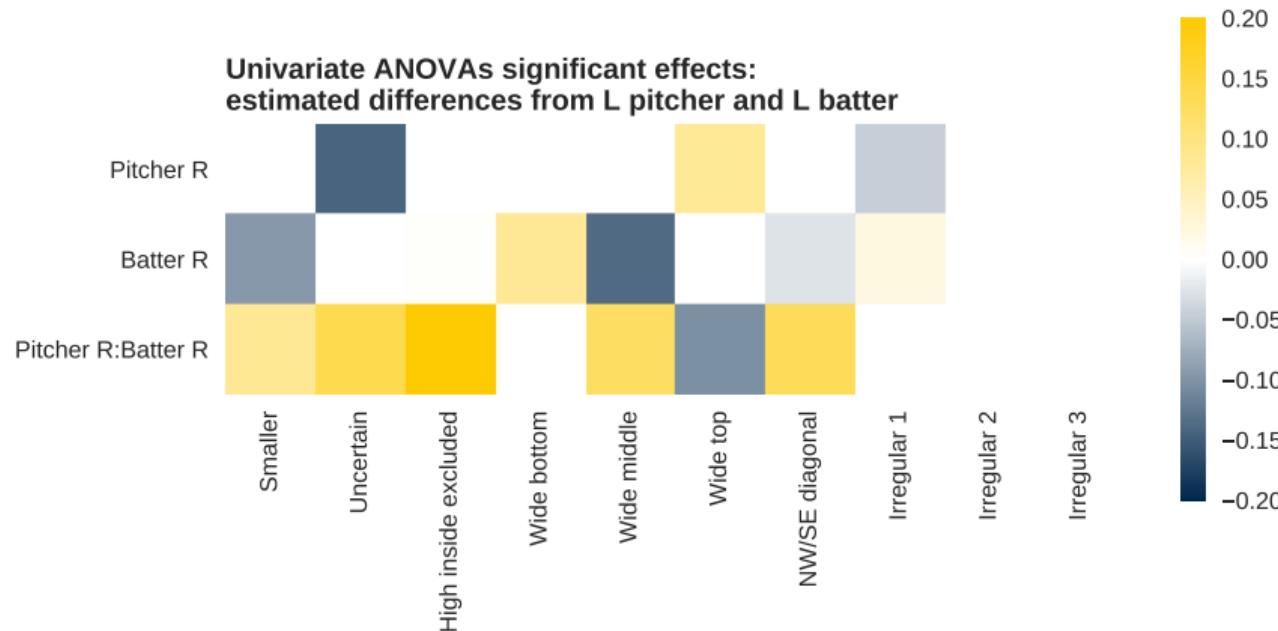
Model : component ~ umpire + ball count \* strike count



# Inference

## Univariate Analyses of Variance

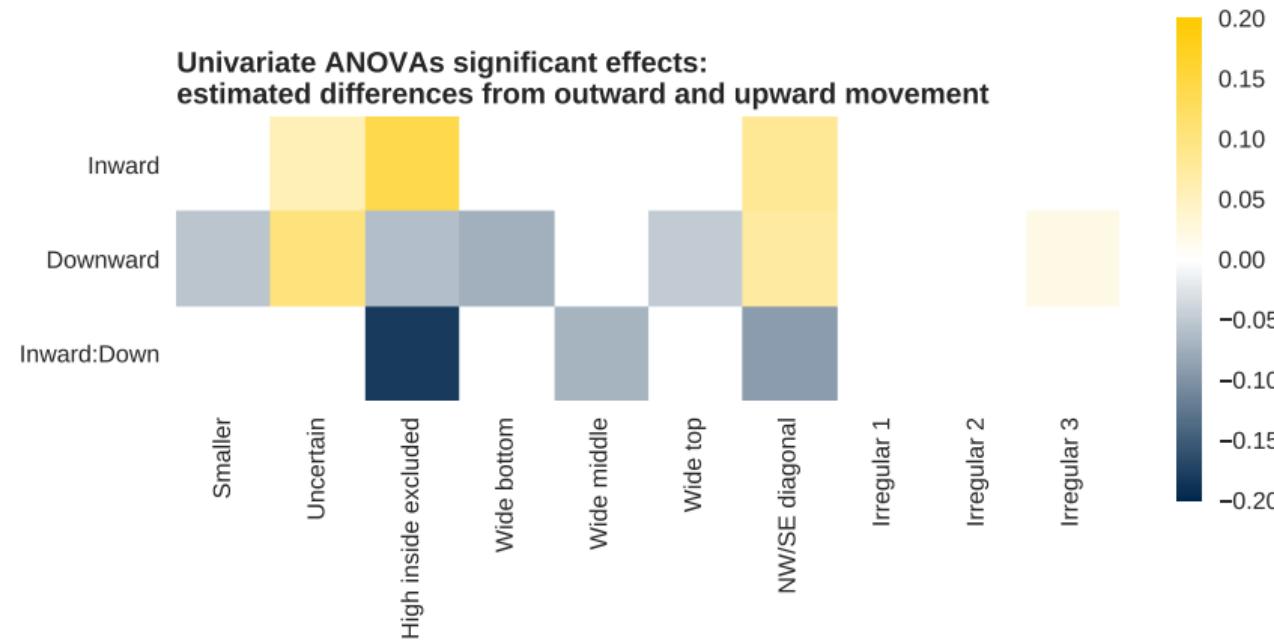
Model : component ~ umpire + batter \* pitcher



# Inference

## Univariate Analyses of Variance

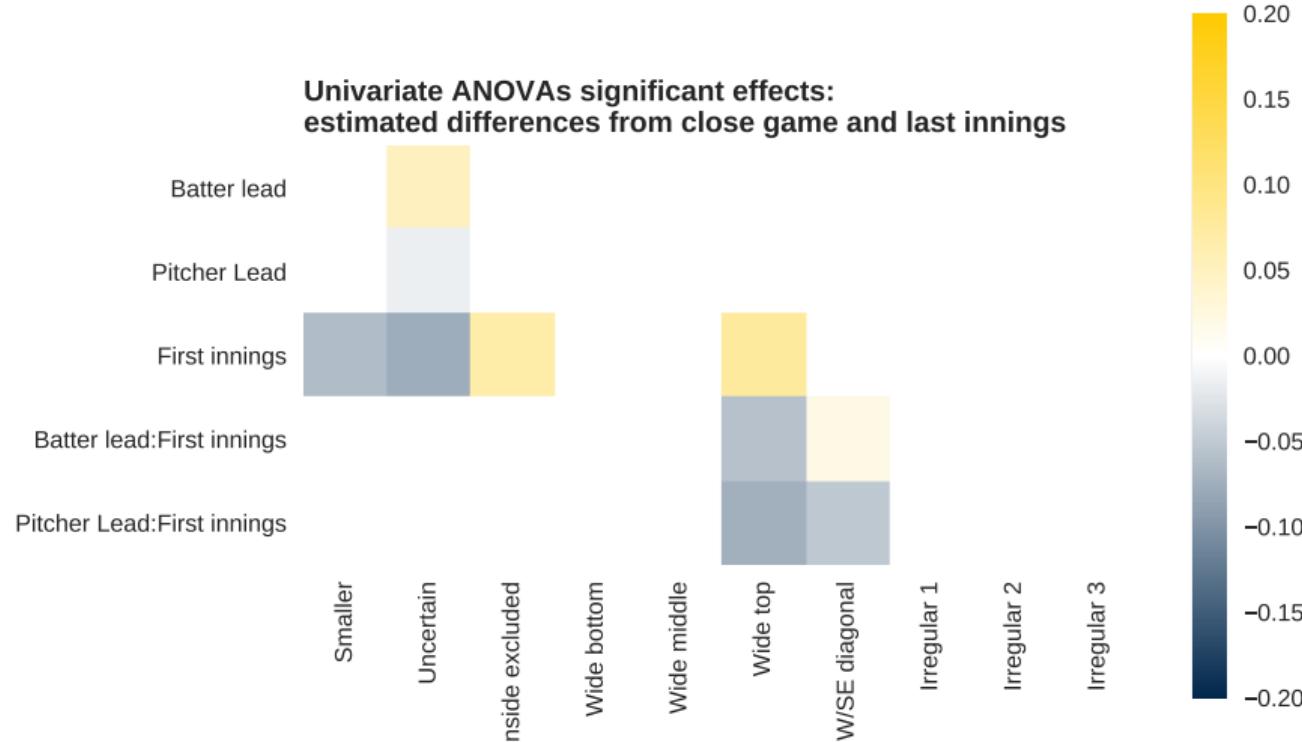
Model : component ~ umpire + horiz. move \* vert. move



# Inference

## Univariate Analyses of Variance

Model : component ~ umpire + score \* inning



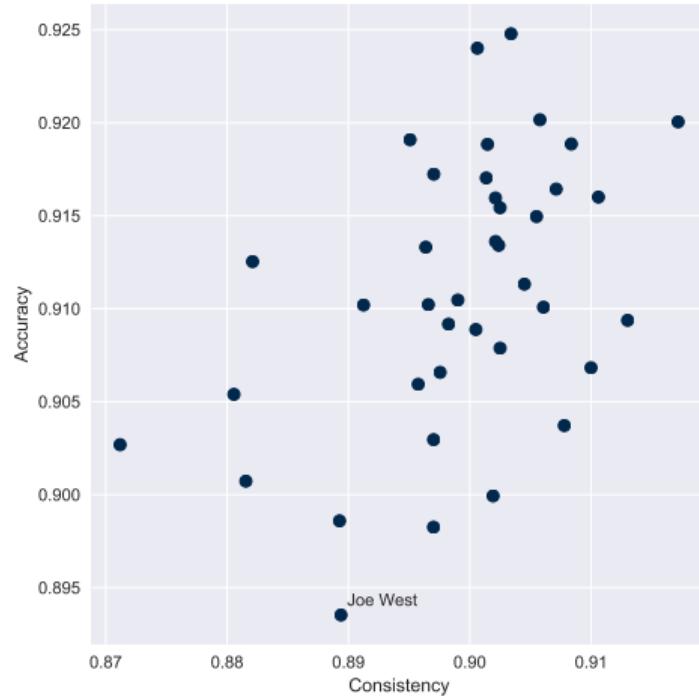
A dynamic action shot of a baseball player in a Los Angeles Dodgers uniform, number 7, wearing sunglasses and a cap, in the middle of a pitching motion. A baseball is captured in mid-air above his hand. In the background, a blurred baseball player in a dark uniform is swinging a bat, suggesting a game is in progress.

# RANKING UMPIRES

# Ranking Umpires

A metric that accounts for consistency and accuracy

- Umpires are frequently ranked by overall accuracy, but our classification procedure allows for umpires to be ranked on consistency, i.e., how similar is an umpire's strike zone across different game situations?
- We construct umpire ratings that weight consistency and accuracy 25%/75%, respectively.



# Ranking Umpires

How do we compare to Bloomberg's "Umpire Auditor"?

Our top 5 umpires from 2018

- ① Mark Wegner
- ② Vic Carapazza
- ③ Pat Hoberg
- ④ John Tumpane
- ⑤ Alfonso Marquez

Bloomberg's top 5[1]

- ① Mark Wegner
- ② Pat Hoberg
- ③ Alfonso Marquez
- ④ Nic Lentz
- ⑤ Sam Holbrook

And the worst, according to our scoring, is "**Country Joe" West.**

# CONCLUSION

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# Conclusion

## Findings

- Low-dimensional encoding of strike zones
- Balls and strikes count has a measurable effect
- Variability between umpires

## Remarks

- Sequential analysis
- Principal component regression
- Multiple testing

## Further analyses

We also considered the following situations:

- Pitcher arm (L/R) and batter stand (L/R)
- Score and inning
- Pitch movement (up/down and inward/outward)

Most yield positive results (omitted for brevity)

Analysis of the variability between umpires

A professional baseball player, wearing a Los Angeles Dodgers uniform with the number 66, is shown from the waist up. He is wearing a blue helmet with the LA logo, a white jersey with blue piping and the word "DODGERS" in blue script, and red pants. He is holding a baseball bat with both hands, one near the handle and one near the top, and has his tongue sticking out. The background is a blurred stadium crowd.

**THANK YOU!**

# References

- [1] **2018 Umpire Ranking.** URL:  
<https://www.bloomberg.com/businessweek/graphics/baseballs-worst-call-of-the-day/#/umpires/ranking/2018> (visited on 04/18/2020).
- [2] **2019 MLB Official Rule Book.** URL: [https://content.mlb.com/documents/2/2/4/305750224/2019\\_Official\\_Baseball\\_Rules\\_FINAL\\_.pdf](https://content.mlb.com/documents/2/2/4/305750224/2019_Official_Baseball_Rules_FINAL_.pdf) (visited on 04/17/2020).
- [3] **Paul Schale.** *MLB Pitch Data 2015-2018.* 2019. URL:  
<https://www.kaggle.com/pschale/mlb-pitch-data-20152018>.

A baseball player in a red and white uniform is crouching on a field, looking intensely at something off-camera. The background is blurred, showing a stadium full of spectators.

QUESTIONS?