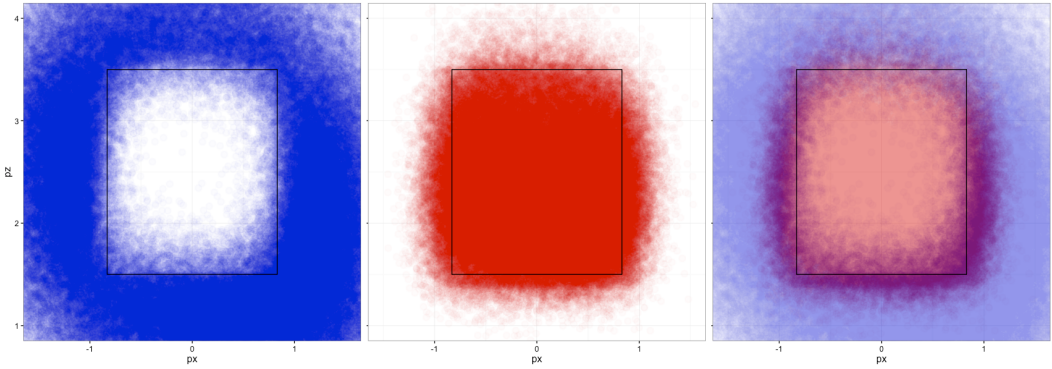
Measuring Umpire Consistency

David J. Hunter

January 11, 2018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Assumptions/Motivations

- Consistency is more important than conformity.
- A consistent zone need not be rectangular, but should be convex.
- Consistency *within* a game is important.
- Different zones for LH and RH batters are OK.
- One egregiously bad call is worse/as bad as several marginally bad calls.

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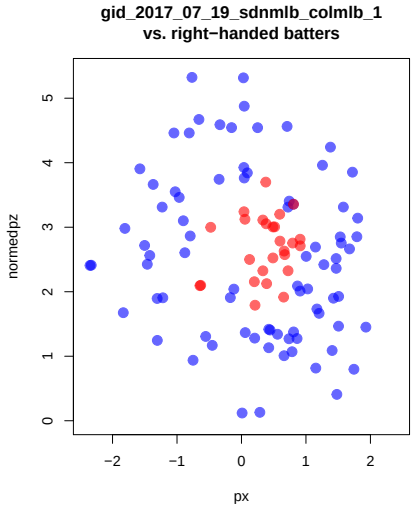
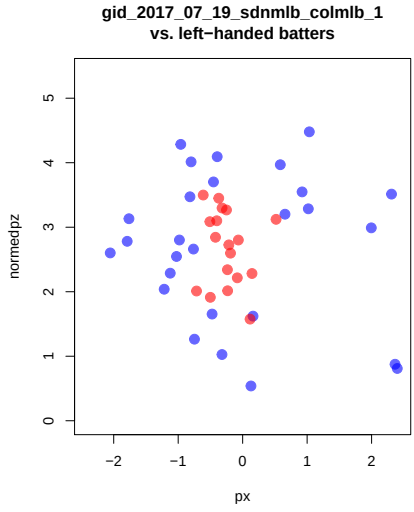
Define established ball and strike zones





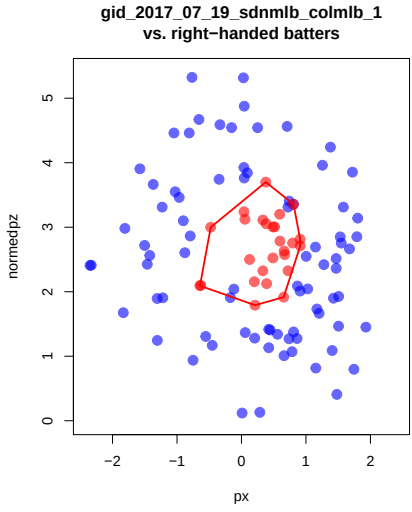
Established Strike Zone: Convex Hull

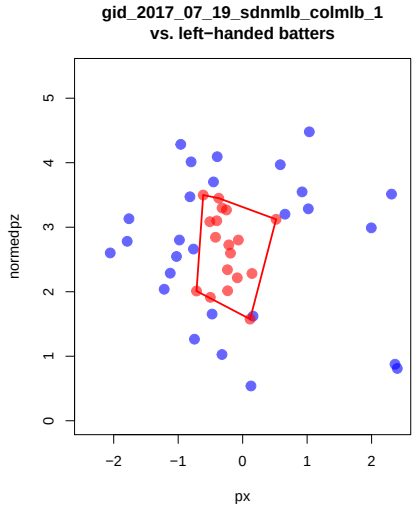
Let H_l denote the open half-plane bounded by the line l. The convex hull of a set of points P is the set

$$S = \bigcap_{\{H_l | H_l \cap P = \emptyset\}} H_l^c$$

When P contains the locations of all called strikes, S is the *established strike zone*.

Established Strike Zone: Convex Hull





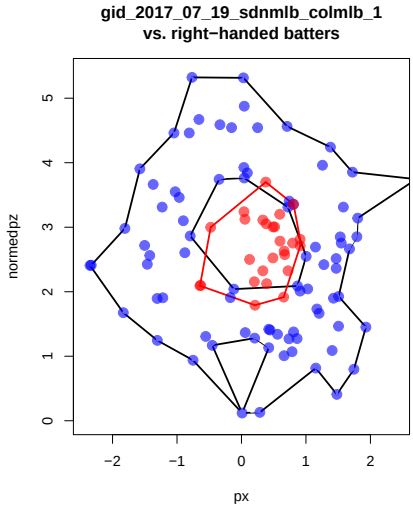
Established Ball Zone: α-Shape?

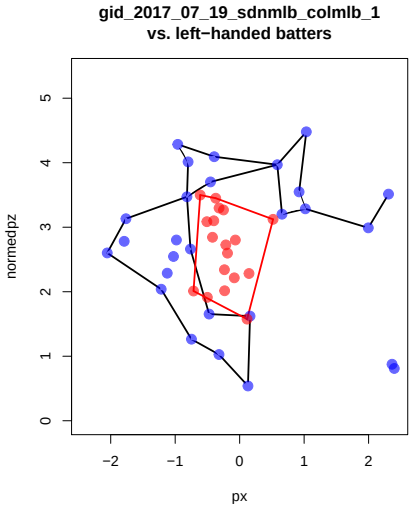
For $\alpha > 0$, let $B_{x,\alpha}$ denote the open ball in $\mathbb{R}^2$ of radius α centered at the point x. Given a set of points $P \subset \mathbb{R}^2$, two points $p_1, p_2 \in \mathbb{R}^2$ are *α-neighbors* if p_1 and p_2 lie on the boundary of some $B_{x,\alpha}$ such that $B_{x,\alpha} \cap P = \emptyset$.

The *α-shape* is the straight line graph formed by drawing line segments between α-neighbors.

- α-neighbors are close together but next to big empty regions.
- The α-shape is the outline of the points P.
- Does not need to be convex or even simply-connected.
- For large α, the α-shape is the boundary of the convex hull.

Established Ball Zone: α-Shape?





Established Ball Zone: α-Hull

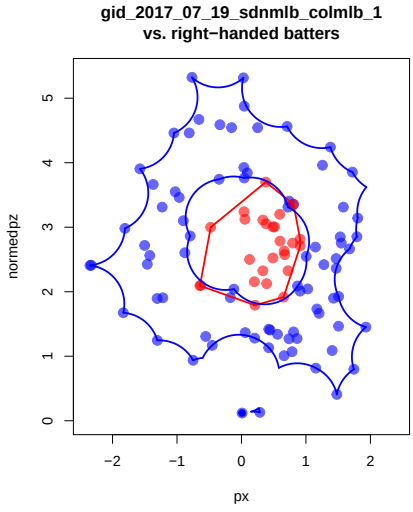
For $\alpha > 0$, let $B_{x,\alpha}$ denote the open ball in $\mathbb{R}^2$ of radius α centered at the point x. Given a set of points $P \subset \mathbb{R}^2$, the α-*hull* of P is the set

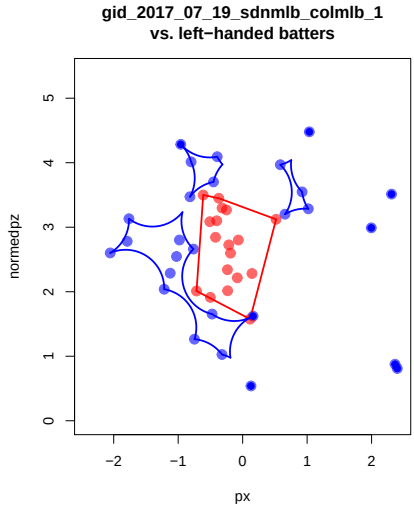
$$X = \bigcap_{\{B_{x,\alpha} | B_{x,\alpha} \cap P = \emptyset\}} B_{x,\alpha}^c$$

When P contains the locations of all called balls, X is the *established ball zone*.

- Approaches convex hull $S = \cap_{\{H_l | H_l \cap P = \emptyset\}} H_l^c$ as $\alpha \to \infty$.
- Intuitively: hole punch.
- May not be simply connected for smallish α.

Established Ball Zone: α-Hull





Inconsistency Index Metric

$S =$ established strike zone (convex hull of strikes)

$X =$ established ball zone (α-hull of balls)

$$\text{inconsistency} = \frac{\text{balls in } S + \text{strikes in } X}{\text{total calls}}$$

- This is a *per game* metric.
- Compute separately for right-hand batters and left-hand batters and add.

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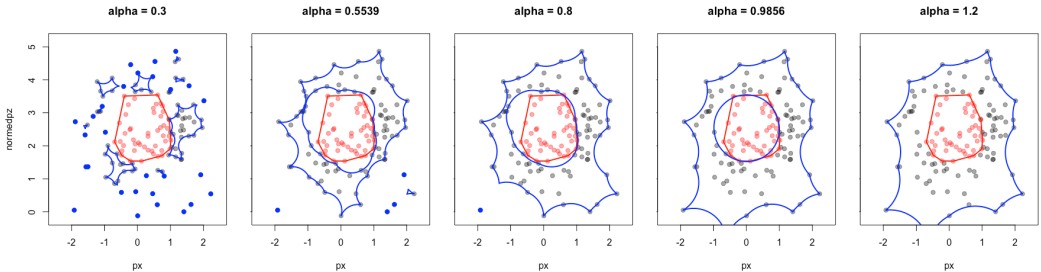
Choosing α

- α too small: Ball zone has lots of components
- α too large: Seems unfair to umpires
- α way too large: Ball zone becomes simply connected
- $\alpha = 0.5539$: $1/3$ rule-book zone width



Correlations: observations

	Games	ZoneSize	Accuracy	BBrate	Krate	Incon
Games	1.00	-0.05	0.05	-0.03	0.30	-0.02
ZoneSize	-0.05	1.00	-0.49	-0.39	0.09	0.34
Accuracy	0.05	-0.49	1.00	-0.01	0.27	-0.65
BBrate	-0.03	-0.39	-0.01	1.00	-0.24	0.09
Krate	0.30	0.09	0.27	-0.24	1.00	-0.14
Incon	-0.02	0.34	-0.65	0.09	-0.14	1.00

- Walk rate uncorrelated to inconsistency, accuracy.
- Smaller zones tend to be more accurate and consistent.
- Inconsistency is moderately correlated with accuracy.

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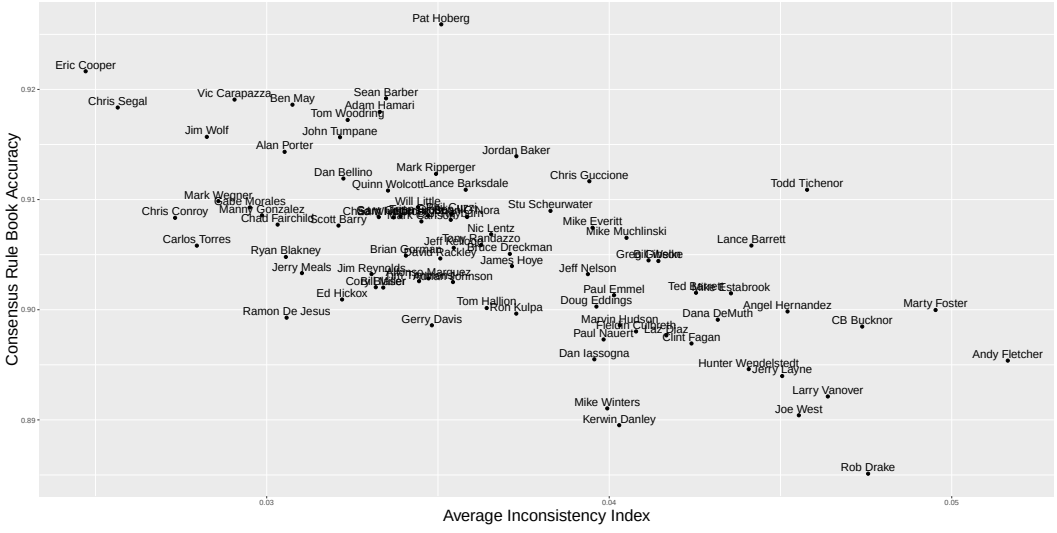
Accuracy vs. Inconsistency ($r = -0.65$)

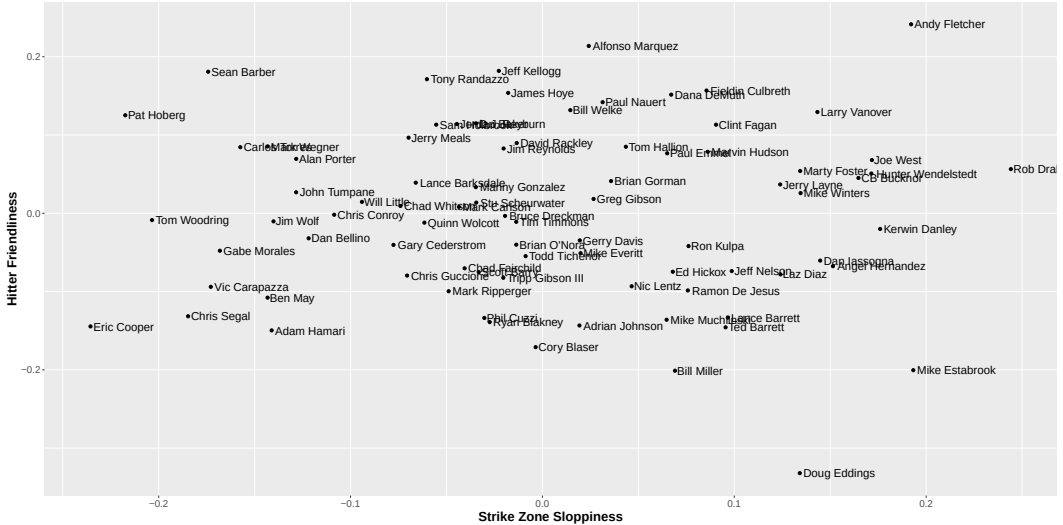


Principal Component Analysis

```
Standard deviations (1, .., p=5):
[1] 1.43 1.21 0.87 0.66 0.54

Rotation (n x k) = (5 x 5):
             PC1   PC2    PC3    PC4   PC5
ZoneSize   0.495 -0.43  0.101 -0.642  0.39
Accuracy -0.626 -0.13  0.025  0.066  0.77
BBrate   -0.089  0.68 -0.478 -0.536  0.10
Krate    -0.179 -0.56 -0.784 -0.019 -0.21
Incon     0.568  0.16 -0.383  0.543  0.46
```

Plot of Components



References

- Data from MLBAM.
- R packages: alphahull, pitchrx, baseballr
- Source code on GitHub: `djhunter/inconsistency`