Redefining the Penalty Kick: Does the Punishment Fit the Crime?

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01

THE PROBLEM
Men’s World Cup 2018 Scoring Percentages

<table>
<thead>
<tr>
<th>Penalty Kick Scoring</th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Number of PKs</td>
<td>29</td>
<td></td>
</tr>
<tr>
<td>PK Goals Scored</td>
<td>22</td>
<td></td>
</tr>
<tr>
<td>Scoring Percentage</td>
<td>75.86%</td>
<td></td>
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</tbody>
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<table>
<thead>
<tr>
<th>Regular Play Scoring within the Box</th>
<th></th>
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<tbody>
<tr>
<td>Shots Taken within the 18</td>
<td>940</td>
<td></td>
</tr>
<tr>
<td>Goals Scored</td>
<td>111</td>
<td></td>
</tr>
<tr>
<td>Scoring Percentage</td>
<td>11.81%</td>
<td></td>
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</tbody>
</table>
Goal:

- Re-configure the penalty kick to make for a more fair penalty kick opportunity
  - Reshape or move the location of the kick
BUILDING THE MODEL
● No change in box shape
● Model for how expected goals change at different penalty kick distances and angles
  ○ Calibrate model to ~75% for current penalty kick distance and angle
● Find a new location and angle with reduced expected goals
Generalized Additive Model

- Beta family, logit link
- Used shot data excluding penalty kicks
  - 1638 observations
- Original Model:
  - Used distance to goal, angle to goal and distance to closest defender
  - Not predicting correctly for PK
- Considered adding defenders behind ball variable to the model
  - Decide between linear or smoothed term
Smoothing Spline More Appropriate for Defenders Behind Ball

- Seems to have an exponential relationship
  - Not captured linearly
- K value of 9 not needed
Final Model

● Generalized Additive Model
  ○ Response: Statsbomb Expected Goals
  ○ Predictors
    ■ Distance to closest defender, $k = 9$
    ■ Angle to goal, $k = 9$
    ■ Distance to goal, $k = 9$
    ■ Defenders Behind Ball, $k = 3$

● Prediction for Current PK:
  ○ 74%
The Penalty Arc

- Arc 18 yards from goal, outside marks at 50°
- If fouled outside arc, brought into closest mark
- If fouled in arc, placed on arc at horizontal location of the foul
THANKS & QUESTIONS?