**Pitch Design: Art or Science?**

Baseball Track

1. **Introduction**

Pitching is often referred to as an "art" rather than a science. As organizations have improved their data sources and analytical techniques, the pendulum has started to shift more towards viewing pitching as a science, albeit a highly complicated science. While understanding that a given pitcher is particularly effective is a manageable task, understanding why it is particularly effective has far more importance beyond the results of a given plate appearance. Machine learning methods have become more advanced but also more block box and less interpretable. While explanatory modeling techniques have developed slower than overall machine learning, some methods can still be used to help illuminate complicated models. This study uses explanatory modeling techniques to help explain a pitch's effectiveness.

1. **Methods**

This project centers around the use of explanatory modeling. The primary methods used throughout the paper are Shapley values and Local Interpretable Model-agnostic Explanations (LIME). However, explanatory modeling requires a model to be explained. In our paper, we test various deep learning black box models with many inputs, including different neural network frameworks, gradient-boosted machines, general additive models, and extreme gradient boosting. Each of these models can be viewed as a version of a "pitch grader," which takes various features about the pitch such as its velocity, movement, release point, and those numbers relative to the pitcher's averages to predict the change in run environment as a result of the pitch. From there, we can use explanatory modeling to explain and decode the model and explain what each pitch is leading to the predicted result.

1. **Results**

The results of this paper are not a specific p-value or result but rather the framework and tools to help explain why a pitch is effective. This paper allows us to take a given Major League pitch and explain what factors are most affecting why the pitch is likely to be successful or not.

1. **Conclusion**

This study's results can help baseball consumers and guide the organization's in-game strategy and pitcher development. Firstly, this study creates a fun tool that could allow a fan to watch a pitch get hit for a home run and then be able to see the lack of velocity difference between the pitcher's fastball and changeup leading to a substandard result or see an incredible back-door slider and understand how the interaction of horizontal movement and spin rate contributed to fooling the batter. Likewise, this methodology can help an organization guide and develop pitchers by identifying the strengths and weaknesses of their overall repertoire or what went wrong at an individual pitch level. Similarly, an organization can reverse engineer this methodology to help understand what tweaks made by a pitcher in a future game would lead to the most success and thus focus their development.