Final Proposal: Pitching Strike Zone Analysis with Pressure Pad Project

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May 2025

1 Abstract

Based on the problem of not having many online tools to track data from a pitches bullpen and analyze the data all in one, especially if you are not at a professional level, my goal is to create an interactive user interface of a strike zone used to plan out where a pitcher wants to throw a specific pitch, then have a pressure pad at home plate that can pin point where the pitch ended up and relay that spot back to a device. The device would also be used to store the data that will be used to calculate, possibly an accuracy heat map, and pitch command metrics ranging from the basic strike percentage to more detailed data like miss distances.

2 Introduction

Baseball, especially at the college and higher levels, demands very precise and consistent - pitching performances. Coaches and players often rely on printed strike zone charts to manually record each pitch, track accuracy, and calculate performance statistics like strike percentage or pitch type effectiveness. While this method is familiar across the whole sport, it is pretty inefficient, difficult to maintain over time, and prone to errors, especially when - coaches have to dig through piles of paper or perform calculations manually on almost a daily basis. This project aims to try and modernize that process through a pitching strike zone analysis system. The primary component is a digital platform, possibly a website, mobile app, or desktop application, that would allow coaches or players to track each pitch on a visual strike zone interface. The system will automatically calculate useful statistics, store data for future use, and allow sorting by pitch type or location. Additionally, the project would try to explore a secondary, more experimental physical component using pressure-sensitive pads that could track if a pitcher hit the intended target and potentially measure force to estimate velocity. This would require custom hardware capable of withstanding high-speed impacts due to the rise in pitching velocity, and integrate with the computer or app interface. By combining a digital interface with some physical feedback, this project is aimed to lower the burden and inefficiency of manual tracking while keeping the quality and accessibility of pitching data that helps coaches focus more on training for the better of their team and players and less on paperwork.

3 Survey

Modern technology has greatly changed the way baseball teams analyze the game and how they are able to develop players. From tracking how a player moves to using automated strike zones, these new tools are making it much easier to measure performance inside and outside of games. However, there are still a lot of gaps in who can use this relevant technology and how it works. This literature review looks at different studies on baseball technology, starting with general uses of pressure sensors and then looking at research about strike zones and new automated systems being used today. The literature reveals the growing - trends in baseball technology aimed at improving pitching accuracy and performance analysis to better pitchers at many different levels. Early research on pressure sensors and baseball analytics provides a foundation, while recent studies on automated strike zones and pitch-tracking systems highlight the relevance of sensor-based solutions. This review really shows the need for further innovation in strike zone analysis, especially bringing the proposed pressure pad system to light as a valuable tool for coaches and players seeking more accurate and efficient data collection.

3.1 General Applications of Pressure Sensors

Hobson discusses the Swing Catalyst system [1], which uses a pressure sensor to analyze a player's back foot and back leg load in a baseball swing. While this research focuses on hitting mechanics rather than pitching, it shows how pressure-sensitive technology can create heat maps for performance analysis. Similarly, an article by Technetron Electronics [2] provides a detailed guide on using pressure sensors with Arduino, offering foundational knowledge for implementing sensor-based systems.Though neither study directly addresses pitching, they lay the groundwork for understanding pressure sensor technology in a baseball-related matter.

3.2 The Idea of Automated Strike Zone Systems and What They Are

Major League Baseball's (MLB) commissioner Rob Manfred and Ronald Blum [3] discuss the possible implementation of the Automated Ball-Strike (ABS) system [4], often referred to as "robot umpires" which is a system that would call every pitch and relay the ball or strike call back to the home plate umpire through an earpiece, or using a replay system that allows players to challenge certain calls when they want. These sources explain how automation improves accuracy and reduces human error in umpiring. Steve Pokin [5] then extends this discussion by examining the obvious differences between digital strike zones shown on broadcasts and the actual MLB definition of one. These studies emphasize the challenges of trying to make strike zone calls more consistent and emphasize the potential for technology-based solutions like the one proposed in this research.

3.3 Data Collection by Technology in Baseball

Pourciau from TopVelocity [6] introduces the metrics Stuff+, Location+, and Pitching+,-which evaluate pitch characteristics such as velocity, spin rate, and placement to use to improve pitchers training. These data-driven approaches highlight the increasing role of analytics in modern baseball. Also, in Ming-Chia Yeh's article I found [7], they explored the use of a sensor-embedded baseball to analyze pitching mechanics. Their study connects finger attributes to spin rate and velocity, showing the potential for embedded sensors in performance assessment. Even though they focused on data collected from within the baseball itself, their findings back up the importance of precise pitch tracking which is an element important to this research.

3.4 New Technologies for Pitch Tracking

These newer resources discuss real-time pitch-tracking systems that closely line up with the goals of this study. For example, SensorEdge's SensorMound [8] utilizes over 2,000 sensors to provide biomechanical feedback on pitching mechanics, offering relevant data about stride length, weight distribution, and foot orientation. Similarly, Rapsodo's Pro 2.0 [9] uses dual-camera technology to track over 20 pitching metrics like pitch speed, ball spin rate, and vertical and horizontal movement. It also generates video and 3D visualizations to make practice more realistic and helpful for pitchers. Finally, Command Trakker [10] presents an interactive pitching target that records pitch location and type, mirroring the intended functionality of this project's possible pressure pad system and interactive strike zone user interface.

4 Design

1. Computer User Interface- Design a simple and intuitive strike zone UI, create backend storage, use a set of rules to determine strike or ball call based on pitch location, add filtering by pitch type, display stats visually if needed.
2. Coding for stats calculation or data representation
3. Physical Pad- research types of pressure-sensitive pads or target sensors, test durability and accuracy under higher baseball-level forces, prototype the basic pad integration with a computer using USB or Bluetooth, record the contact and store as specific data.

5 Evaluation Plan

My testing would not be very expansive, but while putting the project together, I will need to test the user interface to make sure there are not any bugs with using the strike zone or doing any of the data storing or calculations. I would also be doing a simple drop of a ball onto the pressure pad to test that it works and to see how accurate it is if I end up making it location-based, not just hit or miss-based. After these simpler tests, I would then test ways to hold the pad up, and do some full intent throws with a camera set up behind the pitcher and zoomed into the pad to evaluate the location accuracy of the pad.

6 Contributions

This project will contribute to both the modern baseball training wave, the coaching community, and the field of sports technology in many different ways. The main thing I wanted to focus on was digital efficiency in the hope that a project like this would replace outdated paper tracking systems like all the excessive pitching charts I have dealt with in my career. In the best-case scenario, this project would be a more streamlined, user-friendly app that can be adapted for desktop, web, or mobile use. Another big contribution would be real-time analysis of performance stats. This would mean coaches and players can access live statistics like strike percentages and pitch accuracy, saving time and improving decision-making for teams and players to become better and more efficient. A smaller but more appreciated contribution would be the data organization and storage aspect of the project. In the past, pitchers' bullpens would take a while to see stats and be able to use them with the paper charts, but sessions hopefully can be stored digitally right when the throwing is finished, making it easier to track progress over time without sorting through paper records. A more difficult contribution would be pushing towards the innovation of physical pitcher feedback. Exploring pressure-sensitive pads introduces a new hardware element that is rarely used in bullpen settings, with potential for future integration into training equipment due to the constant growth of pitchers and velocity training in this modern era of baseball. While designed with college teams in mind, this project can easily be scaled for use in professional, high school, or even youth baseball settings, depending on the complexity of it.

7 Risks

Despite my believing there is strong potential for this project, a few possible risks have come to my attention. The first one that came up is hardware feasibility. This is because the physical pressure pads may be too fragile due to the wide range of force production possible with a baseball, expensive due to a limited budget, or too complex to prototype with limited time and skills. Expanding off of this risk, another one is sensor accuracy. The reliability of things like impact detection and velocity readings through pressure pads is not guaranteed without access to higher-quality equipment or lab conditions, again due to the high force output and possible spin rates. On the computer side of the project, there may be user interface challenges since I am trying to design an intuitive and error-free input system for pitch tracking, which might require more refinements than anticipated. Also, managing the data collection and ensuring storage and retrieval of data goes smoothly without a full backend or cloud setup may require extra attention to avoid bugs or data loss. In consideration of the project overall, a risk for me could be time constraints. Being able to balance both the software and hardware development may be challenging within a semester. The digital portion will definitely be prioritized, but the physical portion may remain at the prototype stage or have to be simplified, depending on usefulness or progress towards the end of the semester.

8 Special Resources

1. Computer
2. Arduino/Breadboard
3. Extra long Wires
4. Pressure Pads or Force Sensors

5. Baseball or different material balls
6. Camera with slow motion video capability

9 Timeline

- Week 1 - Getting started
- Week 2 - Technical report v0 due
- Week 3 - Data architecture diagram v0 due (hand drawn)
- Week 4 - Graphical abstract v0 due (hand drawn)
- Week 5 - Data architecture diagram v1 due, graphical abstract v1 due
- Week 6 - Technical report v1 due (introduction, literature review, v1 of data architecture diagram, v1 of graphical abstract, methods (data set(s), software, analysis plan), references)
- Week 7 - [Spring break]
- Week 8 - Data architecture diagram v2 due, Graphical abstract v2 due, Poster v0 due (hand drawn)
- Week 9 - Project video storyboard due (hand drawn); portfolios and gitlab review
- Week 10 - Technical report v2 due (feedback incorporated, v2 data architecture diagram, v2 graphical abstract, more methods, first results)
- Week 11 - Poster v1 due (digital, and henceforth)
- Week 12 - Data architecture diagram v3 due, graphical abstract v3 due
- Week 13 - Demonstration video v1 due [Academic Fair on Wednesday, no class meeting]
- Week 14 - Technical report v3 due (feedback incorporated, v3 data architecture diagram, v3 graphical abstract, all methods, all or almost all results)
- Week 15 - Poster v2 due (feedback incorporated, v3 data architecture diagram, v3 graphical abstract, all results, all visualizations); Demonstration video v2 due (feedback incorporated, v3 data architecture diagram, results, visualizations); portfolios and gitlab review
- Week 16 - Final versions of all deliverables are due Wednesday, May 14th, at 5:00 PM.

References

[1] Cameron Hobson. "Pressure Sensor - Creating the Back Leg Load." In: *Bertec* (2020).

[2] Content Manager. "How to use a pressure sensor with an Arduino?" In: *Technetron Electronis* (2025).

[3] Ronald Blum. "What is a strike in baseball? Robots, rule books, and umpires view it differently. Associated Press." In: *AP News* (2023).

[4] Rob Manfred. "Rob Manfred Says MLB Will Likely Introduce Automated Strike Zone System in 2024." In: *Bleacher Report* (2022).

[5] Steve Pokin. "Pokin Around: Why doesn't the digital-strike-zone-box match the real MLB strike zone?" In: *Springfield Daily Citizen* (2023).

[6] Brent Pourciau. "Pitch Design: What Is Stuff+, Location+, and Pitching+?" In: *TopVelocity* (2024).

[7] Ming-Chia Yeh. "Using a Sensor-Embedded Baseball to Identify Finger Characteristics Related to Spin Rate and Pitching Velocity in Pitchers." In: *MDPI* (2024).

[8] Sensor Edge. "Baseball Sensor Mound". In: *Sensor Edge Sports, Inc.* (2024).

[9] Rapsodo. "Pro 2.0 - Baseball's Ultimate Training Tool: Rapsodo® Baseball." In: *Rapsodo Baseball Inc.* (2024).

[10] Command Trakker. "Command Trakker Command Pitching Target". In: *Kinemetrica* (2024).