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PitchTrack: Baseball Pitch Tracking via Computer Vision Methods

I. Introduction

The dynamic and fast-paced nature of baseball presents unique challenges in sports analytics, particularly in the detection and tracking of baseball pitches from video sequences. This project aims to explore traditional computer vision techniques to develop a system capable of not only detecting the baseball within video frames but also tracking its trajectory and investigating the potential for classifying different types of pitches. This is pivotal for enhancing the analytical capabilities in sports technology, providing deeper insights into game dynamics and player performance.

II. Methodology

Our methodology is designed to tackle the challenges of accurately detecting and tracking a baseball's trajectory and exploring the feasibility of pitch classification through systematic stages. Each stage builds upon the last, ensuring a comprehensive analysis that leverages the strengths of various computer vision approaches to enhance the precision and effectiveness of sports analytics.

a) Baseball pitch detection

The ***Hough Circle Transform*** is a well-established technique in computer vision used for detecting circles in images. This method is particularly suitable for identifying objects like baseballs that typically appear circular in video frames. By converting the image to a grayscale format and utilizing edge detection algorithms, the Hough Circle Transform can isolate circular shapes based on their geometric properties.

However, The high velocity of baseball pitches often results in motion blur, which can obscure the edges of the baseball in video frames, making it difficult for edge detection algorithms to identify the circle accurately. The possible solution is utilizing ***high-resolution video recordings*** with a high frame rate to ensure that each frame captures a clearer and more defined shape of the baseball, facilitating more accurate detection. Furthermore, we can implement ***motion deblurring*** techniques that preprocess the video frames to sharpen the image thereby enhancing the effectiveness of the Hough Circle Transform. Additionally, using ***adaptive thresholding*** in edge detection can help in better delineating the ball from the background even under less-than-ideal conditions.

b) Pitch tracking and tracing

Effective pitch tracking and tracing in baseball is critical for analyzing the dynamics of each pitch with high precision. The ***Kalman Filter*** is an algorithm that predicts the future state of an object based on its previous states, accounting for errors in measurement and estimation. It's particularly useful in tracking applications where precision and reliability are crucial despite uncertainties and

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noise in data. By updating its estimates with every new measurement, it provides a refined prediction of the object's position and velocity.

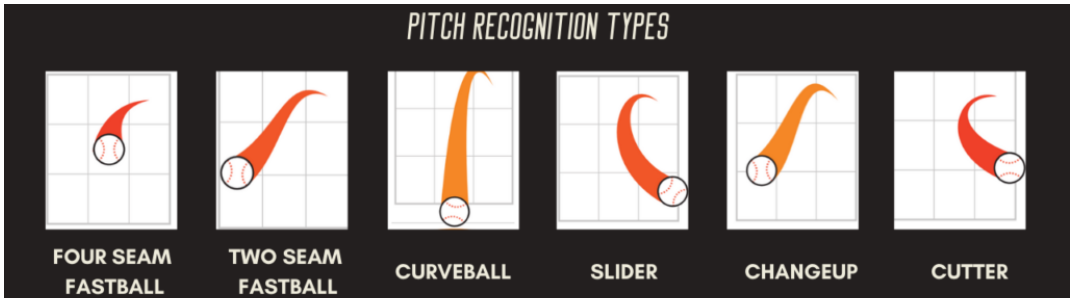
In the context of object tracking, such as following a baseball's path in a pitch, the Kalman Filter estimates the ball's position in each frame of the video. It starts with a prediction based on the object's known dynamics, adjusts this prediction with actual measurements, and iteratively refines the object's estimated trajectory. This process helps in maintaining a continuous and accurate track of the baseball, even when direct observations are noisy or partially obscured.

The extreme speeds at which pitches are thrown can lead to significant challenges in tracking. To mitigate these, the filter parameters may be fine-tuned to better handle the expected velocity and acceleration ranges of different pitch types.

c) Possible Extension: Pitch classification

A possible extension of this project is the classification of pitch types, while influenced by a variety of factors including the pitcher's mechanics and the ball's velocity, can significantly benefit from analyzing the visual trajectory of the pitch. By examining the trajectory of baseball moving from the pitcher's hand to the catcher's mitt, we can categorize the type of pitch:

- 4-seam Fastball: Exhibits a near straight line.
- Curveball: Shows a noticeable drop in the vertical direction.
- Slider: Moves from right to left for a right-handed pitcher.
- Changeup: Moves from left to right for a right-handed pitcher.



We can adopt rule-based classification to categorize baseball pitches by setting predefined criteria for it to categorize baseball pitches by their trajectory, according to the characteristics of different pitch types.

In conclusion, "PitchTrack" leverages traditional computer vision methods to enhance baseball pitch detection, tracking, and classification. By integrating techniques like the Hough Circle Transform and the Kalman Filter, this project aims to foster advancements in the application of computer vision in sports analytics.