Trajectory detection and boundary estimation for badminton shuttlecock using 3D position estimation

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1 Problem Background

Badminton is a popular sport around the world and similar to other sports, a line judgment call can decide games. Additionally, object tracking for sports events is an ever growing field of interest in computer vision. In this project, we would like to focus on tracking a shuttlecock for a badminton game with the goal of determining if the shuttlecock is inside or outside of the court boundary at various points during the game.

This implementation could serve as an automatic line detection system for the game. However, it is extremely difficult to implement because the shuttlecock itself is extremely small and the velocity changes inconsistently and drastically during a game.

2 Dataset

The dataset[3] consists of 8000+ image frames extracted from videos of badminton games captured from two stationary cameras at 180 degree angles from each other. Each image contains accurate timestamp metadata that will be useful to help us reconstruct the position of the shuttlecock in 3D

(a) Game from Camera 1

(b) Game from Camera 2

Figure 1: Sample Images from our Datasets

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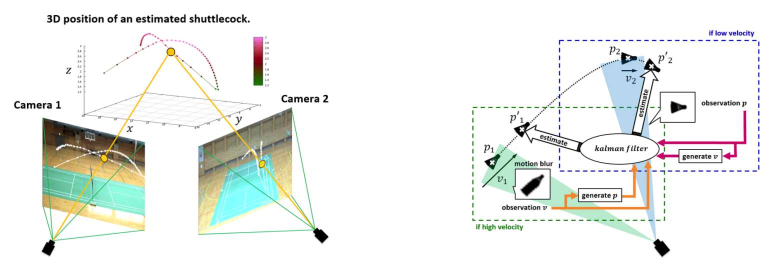
3 Method

To know if the shuttlecock is in bounds or out of bounds, we will track the flight trajectory of the shuttlecock as the game progresses. As stated previously, tracking the shuttlecock presents 3 problems: the shuttlecock moves extremely fast, it is quite small and its velocity changes inconsistently due to its shape and air resistance which leads to motion blur Shishido et. al[1]. Our steps for solving this problem are as follows:

- Estimate the 3D position of a moving shuttlecock in image frames with methods such as background subtraction or blob detection.
- Apply this position to a Kalman filter to get optimal estimates of the state variables over time and track the shuttlecock across frames.
- Generate the 3D structure of the scene.
- Extract the camera parameters from the views.
- Use the camera parameters along with the 3D structure of the scene to triangulate the position of the shuttlecock. Using the position of the shuttlecock, estimate if it is in or out of bounds.



(a) 3D Reconstruction based on images from 2 cameras

(b) A visual representation of the technique to be used in building our model

Figure 2

4 Evaluation

As a baseline evaluation metric, we will determine how accurate our model is at determining if the shuttlecock is within or outside the court boundaries by first utilizing a Kalman filter for predicting the shuttlecock terminal position. Furthermore, we will evaluate the accuracy of an improved variation of the model which will utilize the motion blur techniques discussed in Shishido et. al[1] to reduce the error rate of the predicted terminal position and the actual terminal position.

5 Goals

The goal is to estimate the trajectory of the shuttlecock over time and use the terminal position of the shuttlecock to determine if it is in or out of bounds of the court dimensions. Our secondary goal is to improve the accuracy of the trajectory projection using motion blur techniques.

6 Progress Timeline

- Extract camera parameters of the dataset and estimate the 3D trajectory of the shuttlecock - Feb 15th
- Generate 3D structure of the scene (shuttlecock and court) from the 2 different camera views- Feb 27th
- Estimate terminal position of shuttlecock relative to the court boundary to determine if the shuttlecock is in or out of bounds - March 17th.

References

[1] Shishido, Hidehiko, et al. "A trajectory estimation method for badminton shuttlecock utilizing motion blur." Image and Video Technology. Springer Berlin Heidelberg, 2013. 325-336.

[2] Yongkui, Man, Zhao Liang, and Hu Jingxin. "Application of Kalman filter in track prediction of shuttlecock." Robotics and Biomimetics (ROBIO), 2009 IEEE International Conference on. IEEE, 2009.

[3] Cartron, M. (2022, March 26). Shuttlecock dataset and pre-trained model by Mathieu Cartron. Roboflow. Retrieved February 5, 2023, from https://universe.roboflow.com/mathieu-cartron/shuttlecock-cqzy3/browse?queryText=split