CCEB23060 - Development of Badminton Robot

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Introduction

This research aims to explore the development of Artificial Intelligence (AI) for creating advanced robotic sports assistants to help enhance the training performance of badminton athletes. Firstly, machine learning models are used to accurately predict the trajectory and landing location of a shuttlecock. The **predicted landing coordinates** of the can be used to control a robot to **intercept the falling shuttlecock** at the right time to return the shot back to the player.

Methodologies

1) Data-driven linear regression model

Propagation of collected shuttlecock trajectory coordinates in 3D space via translation and rotation to expand range of input hitting coordinates for the dataset. Trajectory data was then used to train a Gradient Boosting Regressor which is directly used to predict coordinates of shuttlecock trajectory.

2) Equations of motion

Extraction and modelling of Coefficient of Drag(C_D) of a shuttlecock against its flight velocity.

Instead of directly using Machine Learning model to generate the complete set of coordinates, we used it to predict C_D. Then, kinematic equations of motions are used in an iterative manner to calculate the coordinates of the shuttlecock trajectory.

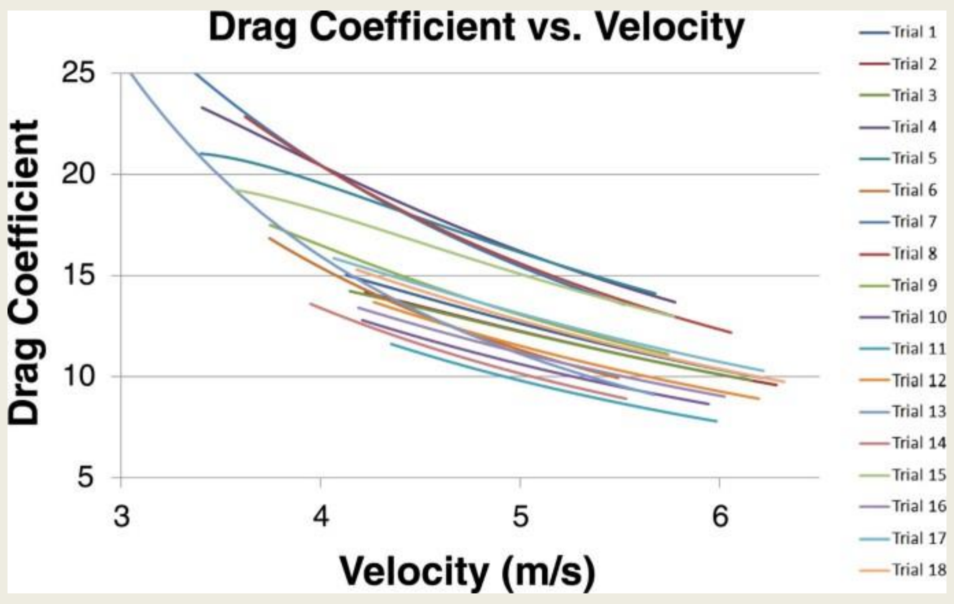

Figure 1: Sample C_D against velocity graph1

Future Work

- Use time series regression to allow for a theoretical limitless range of starting coordinates as the input range.
- Tweak different ways for the robot to intercept and return shuttlecock, achieving the effect of different types of badminton shots like a drive, drop, and even smash, in addition to the current clear shot.

Findings

When **1)** was compared with experimental data, results look satisfactory with a low error rate.

However, this approach has a limitation that the shuttlecock's starting coordinates must be in the model's starting input range. Small errors in the capturing process for the starting coordinates of the shuttlecock will compound into large errors in the predicted trajectory and subsequently the landing spot for the shuttlecock.

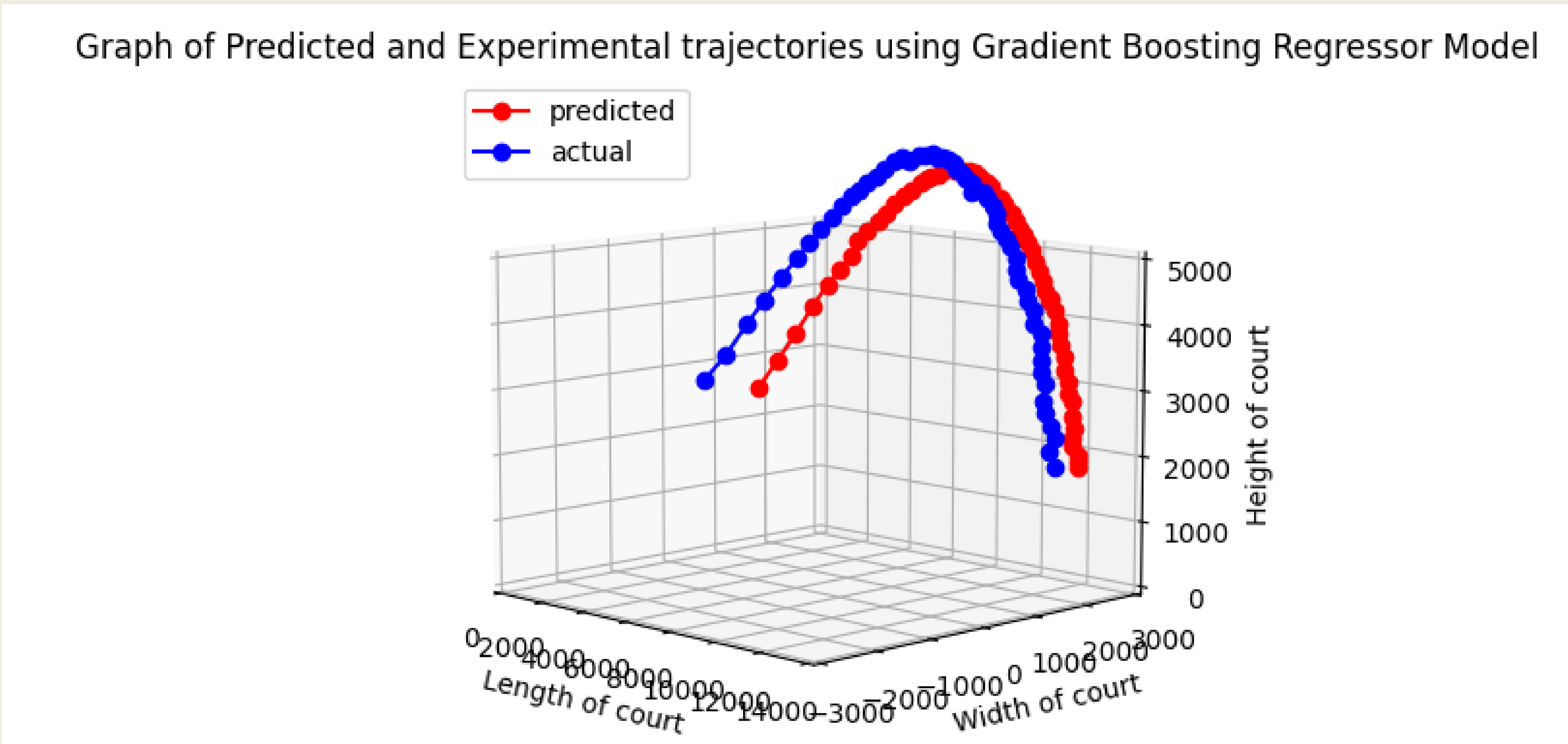

Figure 2: Graph of Predicted and Experimental from GB model

On the other hand **2)** was much more promising as it did not suffer from the problem of limited input range, since it relied on kinematic equations.

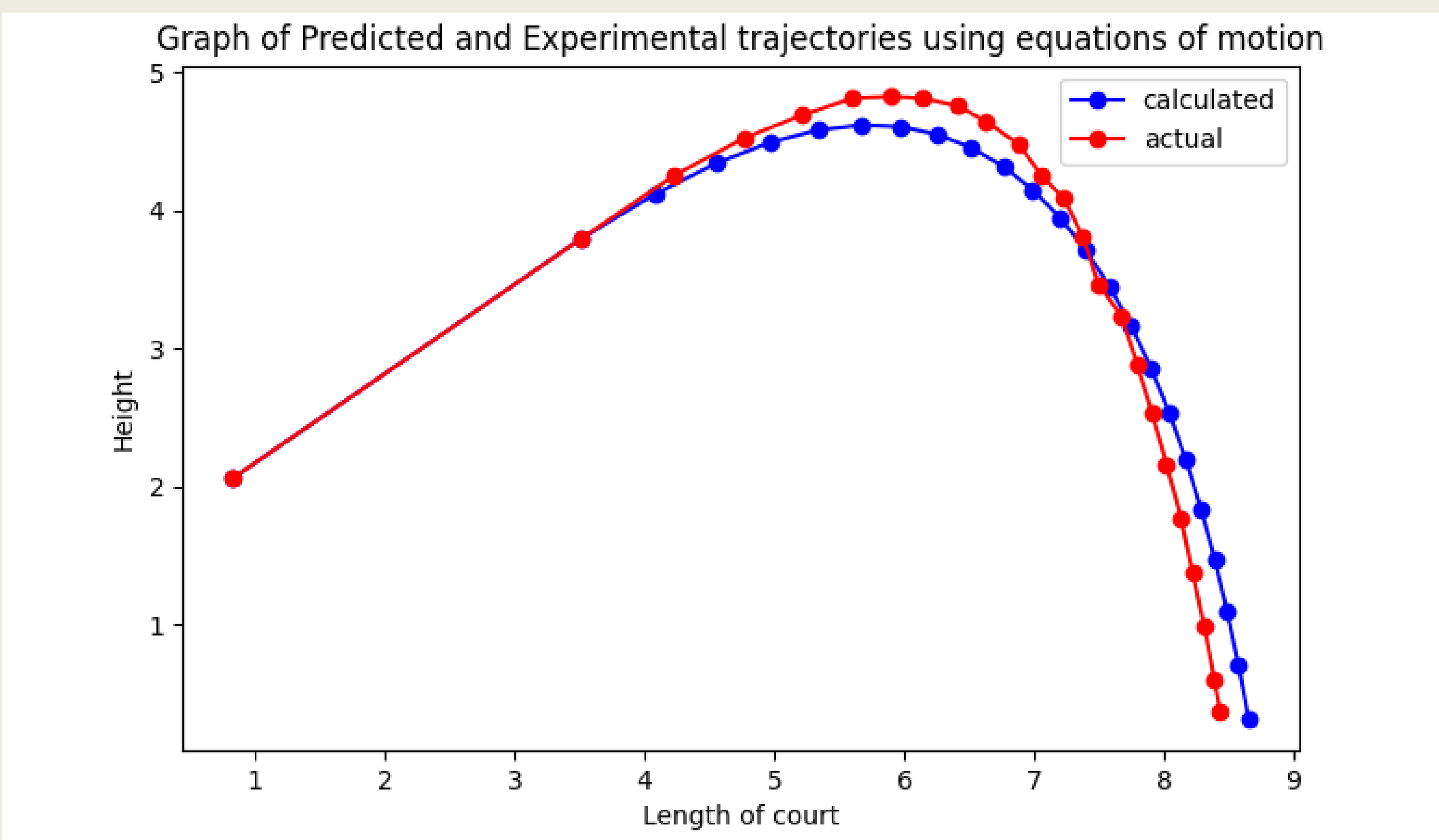

Figure 3: Graph of Predicted and Experimental using kinematic equations

1 Buckmann, J.G., Harris, S.D. An experimental determination of the drag coefficient of a Mens 8+ racing shell. *SpringerPlus* **3**, 512 (2014). https://doi.org/10.1186/2193-1801-3-512