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AI CRICKET UMPIRE

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Abstract: Cricket umpiring, particularly for Leg Before Wicket (LBW) decisions, plays a crucial role in determining match outcomes. Traditional umpiring methods rely on human judgment, which can sometimes lead to errors due to limited reaction time and viewing angles.

To improve accuracy and minimize human error, this paper presents an AI-based cricket umpire system that utilizes computer vision and polynomial curve fitting for LBW decision-making.

The system processes video frames, detects the cricket ball using HSV color segmentation, tracks its movement, and predicts its impact using trajectory analysis.

Keywords: Cricket, AI Umpire, LBW Decision, Computer Vision, OpenCV, Trajectory Prediction, SciPy, NumPy.

1. INTRODUCTION

Cricket is one of the most popular sports in the world, and fair umpiring plays a crucial role in ensuring the integrity of the game. Among the various decisions an umpire must make, the Leg Before Wicket (LBW) decision is particularly challenging.

Since the ball moves at high speeds and can change direction due to spin and swing, umpires often have only a fraction of a second to make their judgment. In professional cricket, advanced tracking technologies like Hawk-Eye assist umpires by predicting ball trajectories.

However, such systems are expensive and not widely available in grassroots and amateur cricket.

Our project, AI-Based Cricket Umpire for LBW Decision Making, aims to bridge this gap by developing an affordable and accessible alternative using artificial intelligence and computer vision.

This system processes live or recorded cricket footage to detect the ball, track its movement, and analyze its trajectory to predict whether the ball would have hit the stumps.

As students interested in computer vision and machine learning, we wanted to build a system that could help in LBW decision-making using AI. Our project uses OpenCV for ball detection, SciPy for predicting the ball's path, and NumPy for processing the positional data.

The system detects the ball, tracks its motion, and predicts whether it would hit the stumps.

If the system determines that the ball would have hit the stumps, it declares the batsman “OUT.” Otherwise, the decision is “NOT OUT.”

This project is an attempt to create an affordable and accessible AI umpiring tool that can be used in local cricket matches and training sessions to improve decision accuracy.

AI-based umpire system that automates LBW decisions using computer vision and trajectory modeling. The system detects the ball, tracks its motion, and predicts its future path using polynomial curve fitting, allowing for accurate and consistent decision-making.

By reducing human error and making umpiring decisions more transparent, the system contributes to fair play and the overall advancement of cricket technology.

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2. LITERATURE REVIEW

The use of technology in sports officiating has grown significantly over the years. Various studies and advancements have contributed to the development of automated decision-making systems, particularly in cricket. Below are some key technologies and research areas that have influenced our project:

2.1 Hawk-Eye Technology

Hawk-Eye is a widely recognized ball-tracking system used in cricket, tennis, and other sports. It utilizes multiple high-speed cameras positioned around the stadium to track the ball's movement in real time. The system processes visual data and reconstructs the ball's trajectory using 3D modeling.

While highly accurate, Hawk-Eye requires expensive infrastructure, making it inaccessible for non-professional cricket matches.

Our project aims to provide a more affordable alternative by using computer vision and machine learning techniques to analyze ball movement and predict trajectories without requiring specialized hardware.

2.2 Computer Vision in Sports Analytics

Computer vision has been extensively used in sports analytics for tasks such as object detection, player tracking, and motion analysis. Research in football, basketball, and tennis has demonstrated the effectiveness of OpenCV-based models in real-time decision-making.

In cricket, computer vision has been used for automated scoring, player movement tracking, and ball-tracking applications. Studies suggest that OpenCV can accurately detect and track fast-moving objects, making it a suitable choice for LBW decision-making in our project.

2.3 Deep Learning for Object Detection and Ball Tracking

Deep learning models, particularly Convolutional Neural Networks (CNNs), have shown promising results in object detection and tracking. Systems like YOLO (You Only Look Once) and Faster R-CNN have been used in sports to identify and track players and objects with high accuracy.

While deep learning provides superior object detection capabilities, it requires extensive training data and computational resources. For this project, we opted for a more lightweight solution using color segmentation and contour detection in OpenCV, which is efficient for real-time applications.

2.4 Trajectory Prediction Using Polynomial Curve Fitting

Several studies in physics and mathematics have explored polynomial curve fitting for trajectory prediction. A quadratic polynomial function is commonly used to approximate the motion of a projectile, such as a cricket ball.

The SciPy library's curve_fit function enables the fitting of a quadratic equation to observed data points, allowing accurate prediction of future positions. This method has been successfully used in ballistics, physics simulations, and sports analytics.

Our project leverages this approach to model the ball's motion and predict its impact point on the pitch.

2.5 Role of AI in Umpiring and Sports Decision-Making

The integration of AI in sports umpiring has been explored in various domains. AI-powered referees have been tested in football to detect offside positions, in tennis to determine whether a ball is in or out, and in cricket for automated no-ball detection.

Research has shown that AI-based umpiring systems can reduce human error and improve decision accuracy. Our AI umpire system aligns with this research by utilizing AI-driven trajectory analysis to enhance LBW decision-making in cricket.

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3.METHODOLOGY

The AI-based cricket umpire system follows a structured approach to detect, track, and predict the ball's movement to make an LBW decision. The methodology involves six key stages:

3.1 Video Input and Preprocessing

The system first captures a cricket match video using OpenCV's cv2.VideoCapture function.

Each frame is extracted and converted into the HSV color space to enhance the detection of the cricket ball.

A binary mask is applied using cv2.inRange(), isolating pixels that match the predefined color range of the ball (e.g., red for a standard cricket ball).

The resulting processed frames are then used for object detection.

3.2 Ball Detection and Tracking

The system applies contour detection using cv2.findContours() to identify the detected ball in each frame.

The system filters out smaller objects to eliminate noise, keeping only objects above a specific area threshold.

The bounding rectangle method (cv2.boundingRect()) determines the ball's exact position by marking its center coordinates.

The detected ball's coordinates are stored frame-by-frame in an array for further trajectory analysis.

3.3 Trajectory Estimation and Curve Fitting

The system compiles the x and y coordinates of the ball's movement.

Using SciPy's curve_fit function, a quadratic polynomial equation is applied to model the ball's motion:

$y = ax^2 + bx + c$

where:

x represents the horizontal position of the ball.

y represents the vertical position (height from the pitch).

a, b, and c are coefficients that define the best-fit curve.

Once the trajectory function is generated, the system predicts where the ball will land by extrapolating the curve.

3.4 Impact Prediction and LBW Decision

The system calculates the predicted impact point of the ball's trajectory.

The system evaluates whether the predicted trajectory intersects the stump coordinates.

The LBW decision-making logic follows these rules:

If the predicted ball path aligns with the stumps and impact occurs within the designated area (outside off-stump, within line of the wickets), the system classifies the decision as "OUT."

Otherwise, it is classified as "NOT OUT."

3.5 Visualization and Decision Display

The predicted impact point is marked on the video frame using cv2.circle().

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The final decision is displayed using cv2.putText():

If LBW is confirmed, a red "OUT" notification appears.

Ifs LBW is not confirmed, a green "NOT OUT" notification is displayed.

The system allows for real-time decision-making, making it useful for both live and recorded matches.

3.6 Performance Evaluation and Testing

The system is tested using multiple cricket match footages to evaluate its accuracy.

The accuracy of ball-tracking is assessed by comparing AI-generated results with manual human umpire decisions.

The final accuracy is calculated as:

Accuracy (%) = (Correct LBW Predictions / Total LBW Cases) × 100

The system's efficiency in handling different lighting conditions, ball speeds, and camera angles is analyzed.

4. EQUATION

Mathematical Equation for Trajectory Prediction
The ball's trajectory is modeled using a quadratic equation:

where:

x represents the horizontal position of the ball.

y represents the vertical position (height from the ground).

a, b, and c are coefficients calculated using curve fitting based on previously detected ball positions.

This equation allows the system to predict the future position of the ball and determine whether it will hit the stumps, forming the basis for the LBW decision-making process.

5. EXPERIMENTAL RESULT

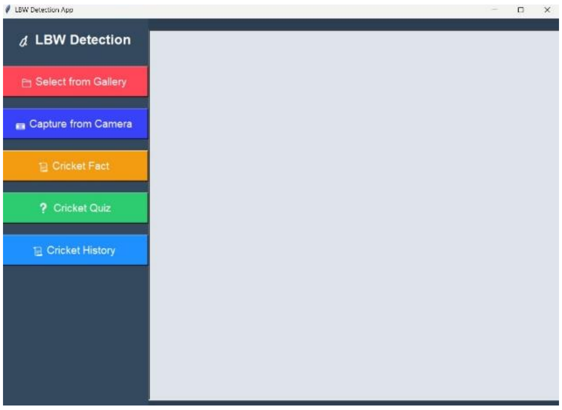

Fig 5.1

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Fig 5.2

Fig 5.3

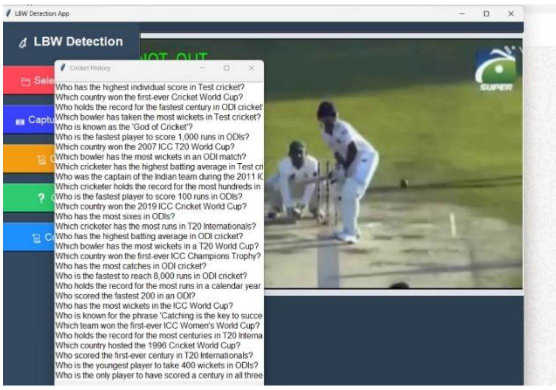

Fig 5.4

6. CONCLUSION

This project successfully demonstrates an AI-based system for automating LBW decisions using computer vision and trajectory prediction. By detecting the cricket ball, tracking its movement, and predicting its impact point, the system enhances the accuracy of LBW decision-making. The use of OpenCV for image processing and SciPy for curve fitting enables a cost-effective solution compared to professional ball-tracking technologies.

While the system performs well under controlled conditions, challenges such as lighting variations, occlusions, and ball color detection need further improvement. Future enhancements, including deep learning for more precise ball detection, multi-camera integration for better trajectory estimation, and real-time processing, will significantly improve the system's reliability and usability.

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With continued advancements, this AI-based umpiring system has the potential to revolutionize cricket decision-making, providing fair and unbiased LBW rulings across different levels of the sport.

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