



Smart Boundary Detection System For Cricket Using Sensor-Based Technology

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Abstract: Cricket is one of the most popular sports worldwide, and accurate decision-making is crucial for fair gameplay. Boundary detection plays a vital role in determining match outcomes; however, traditional methods rely heavily on human judgment, which can lead to errors and delays. This paper proposes a Smart Boundary Detection System using sensor-based technology to automate and enhance the accuracy of boundary decisions. The system utilizes sensors such as Infrared (IR) or Ultrasonic sensors placed along the boundary line, connected to a microcontroller like ESP32 or Arduino. When the ball crosses the boundary, the sensor detects the motion and sends a signal to the controller, which processes the data and generates an output in real-time. This approach reduces human intervention, increases accuracy, and provides faster decision-making. The proposed system is cost-effective, efficient, and can be implemented in both professional and local matches.

Index Terms - Boundary Detection, Cricket Technology, Sensors, IoT, Automation.

INTRODUCTION

Cricket is one of the most widely played and watched sports across the world. It is especially popular in countries like India, Australia, England, and South Africa. In cricket, decision-making plays a very important role because even a small mistake can change the result of the match. One of the most important decisions in cricket is determining whether the ball has crossed the boundary line or not. When the ball crosses the boundary, the batting team is awarded four or six runs depending on how the ball crosses the boundary.

Traditionally, boundary decisions are made by the on-field umpires. Umpires observe the movement of the ball and decide whether it has crossed the boundary line. However, in many situations, the ball moves very fast, making it difficult for the umpire to observe accurately. In addition, poor lighting conditions, crowd disturbance, and human error may lead to incorrect decisions. Even in professional matches, where camera-based systems are used, there are still chances of delay in decision-making.

With the rapid development of technology, especially in the field of embedded systems and Internet of Things (IoT), there is a need to introduce smart automated systems in sports. Automation can improve the accuracy, reliability, and speed of decision-making. This paper presents a *Smart Boundary Detection System* that uses sensor-based technology to automatically detect whether the ball has crossed the boundary line.

The main objective of this research is to design a system that is accurate, affordable, and easy to implement. Unlike expensive camera-based systems used in international matches, the proposed system focuses on using simple sensors and microcontrollers, making it suitable even for local and college-level cricket matches. This system aims to reduce human errors, improve fairness in the game, and provide real-time boundary detection.

The proposed system uses sensor-based technology to detect boundary crossings automatically. Sensors are capable of detecting physical changes in the environment and can provide real-time data. By integrating sensors with microcontrollers, it is possible to create a system that reduces human error and improves decision accuracy.

II. OBJECTIVES

The main objective of this project is to design and develop an automated boundary detection system that improves accuracy and reduces human involvement. The system is intended to be simple, efficient, and suitable for practical use.

The objectives of the system include:

- To detect boundary crossings in real time using sensors
- To reduce dependency on manual umpiring decisions
- To design a cost-effective and portable system
- To provide quick and reliable alerts
- To ensure ease of installation and operation

III. LITERATURE REVIEW

Several research works have been carried out in the field of sports analytics and decision support systems, particularly focusing on cricket. One of the most widely used technologies in modern cricket is Hawk-Eye, which utilizes multiple high-speed cameras to track the trajectory of the ball. This system provides accurate predictions and is widely accepted in international matches; however, its high cost and complex setup limit its accessibility [2].

Another approach involves the use of computer vision algorithms such as YOLO (You Only Look Once), which enables real-time object detection in images and videos. YOLO processes the entire image in a single pass, making it faster than traditional detection methods. Despite its advantages, it requires powerful hardware such as GPUs and a well-established camera infrastructure, which increases the overall cost [4].

Deep SORT (Simple Online and Realtime Tracking) is another technique used for tracking multiple objects across video frames. It combines motion and appearance features to maintain object identity over time. While it improves tracking accuracy, it is heavily dependent on video input and computational resources [5].

IoT-based systems have gained popularity due to their ability to provide real-time monitoring and data collection. These systems use sensors to detect physical changes and transmit data for processing. In sports applications, IoT has been used for player tracking, performance analysis, and decision-making support [6]. Sensor-based systems, in particular, are simple, cost-effective, and suitable for real-time applications.

From the existing literature, it is evident that most advanced systems rely on camera-based technologies, which are expensive and complex. There is a clear need for a low-cost, sensor-based solution that can provide reliable boundary detection without requiring sophisticated infrastructure. The proposed system addresses this gap by utilizing simple sensors and embedded systems to achieve real-time detection.

IV. PROPOSED SYSTEM

The proposed Smart Boundary Detection System is designed to automatically detect whether the cricket ball has crossed the boundary line. The system uses sensors placed along the boundary line, a microcontroller for processing, and an output system to indicate the result.

A. System Architecture

The system consists of the following components:

- Infrared (IR) Sensors or Ultrasonic Sensors
- Microcontroller (Arduino or ESP32)
- Power Supply
- Output Devices (LED, Buzzer, or Display)
- Connecting Wires and Circuit Board

Sensors are placed at regular intervals along the boundary line. These sensors continuously monitor the movement of the ball. When the ball crosses the boundary line, the sensor detects the motion and sends a signal to the microcontroller. The microcontroller processes the signal and activates the output device.

B. Working Principle

The working of the system is very simple and efficient. The sensors are placed along the boundary line in such a way that they can detect the movement of the ball. When the ball crosses the boundary line, it either interrupts the infrared beam or changes the distance detected by the ultrasonic sensor.

Once the sensor detects the movement, it sends an electrical signal to the microcontroller. The microcontroller reads this signal and processes it using the programmed logic. If the signal confirms that the ball has crossed the boundary, the controller activates the output device. The output may include an LED light, a buzzer sound, or a message displayed on a digital screen.

This entire process happens in real time, which means the decision is made instantly without any delay.

C. Advantages of the Proposed System

The proposed system offers several advantages compared to traditional methods:

- Provides real-time boundary detection
- Reduces human errors
- Simple and easy to install
- Low-cost solution
- Works in different lighting conditions
- Suitable for both professional and local matches.

V. METHODOLOGY

The methodology of the proposed system includes hardware selection, system design, implementation, and testing. Each step is important to ensure that the system works accurately and efficiently.

A. Sensor Selection

Sensors are the most important part of this system. Two types of sensors can be used:

Infrared Sensors:

These sensors detect the presence of an object when the infrared beam is interrupted. When the cricket ball crosses the boundary line, it blocks the infrared light, and the sensor detects the movement.

Ultrasonic Sensors:

These sensors measure distance by sending sound waves and receiving the reflected signal. When the ball crosses the boundary line, the distance changes, and the sensor detects it.

Both sensors are accurate, affordable, and easy to use, which makes them suitable for this project.

B. Microcontroller

The microcontroller is the brain of the system. It receives signals from the sensors and processes them using a programmed algorithm. Arduino and ESP32 are widely used microcontrollers because they are easy to program and support real-time processing.

The microcontroller continuously monitors the sensor signals. When a boundary event occurs, the controller processes the signal and activates the output device.

C. System Implementation

The implementation of the system involves both hardware and software components. The hardware setup includes connecting sensors to the microcontroller, configuring input and output pins, and ensuring proper power supply. The sensors are calibrated to detect the cricket ball accurately under different conditions.

The software implementation is carried out using Arduino IDE or similar platforms. The program is written in C/C++ and includes functions for reading sensor data, processing signals, and controlling output devices. Debugging tools such as Serial Monitor are used to test and verify the system.

The system is tested under various conditions to evaluate its performance. These tests include detecting boundary crossings, handling false triggers, and operating under different lighting conditions. The results indicate that the system performs reliably and provides accurate detection in most scenarios.

The implementation process includes the following steps:

1. Installing sensors along the boundary line
2. Connecting sensors to the microcontroller
3. Writing the program using Arduino IDE
4. Testing the system in different conditions
5. Connecting output devices such as LED and buzzer

The system is tested by rolling or hitting the ball across the boundary line and observing whether the sensor detects the movement correctly.

D. Software Tools

The system is programmed using Arduino IDE. The programming language used is C/C++. The program continuously checks the sensor input and generates an output signal when a boundary is detected.

VI. SYSTEM DESIGN DETAILS

The Smart Boundary Detection System is designed using both hardware and software components that work together to detect the boundary crossing of a cricket ball in real time. The main objective of the design is to ensure high accuracy, reliability, and fast response time while keeping the system simple and cost-effective.

The hardware design includes sensors placed along the boundary line, a microcontroller unit, and output devices. The sensors are connected to the microcontroller using digital input pins. The microcontroller continuously reads the input values from the sensors and processes the data using the

programmed logic. If the sensor detects the movement of the ball, the controller immediately activates the output device such as a buzzer or LED indicator.

The system is designed in such a way that it can work in outdoor environments such as cricket grounds. Proper casing is used to protect the sensors from dust, sunlight, and rain. The sensors are placed at equal intervals along the boundary line to ensure accurate detection even when the ball crosses at different points.

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VIII. Comparative analysis of Smart Boundary Detection and Existing System

Feature	Smart Boundary Detection System (Our System)	Hawk-Eye / UltraEdge Systems	Manual Umpiring
Base Technology	Sensors (IR/Ultrasonic) + Arduino	High-speed Cameras + AI	Human Vision
Setup Cost	Low-cost & Affordable	Very Expensive	Nil
Accuracy	High (Sensor-based)	Extremely High	Low (Human Error)
Implementation	Easy for local/college grounds	Complex Setup	No setup needed
Response Time	Instant (Buzzer/LED)	Delayed (Review time)	Instant
Maintenance	Low & DIY	Very High	None
Processing Power	200 GB fast powered	200 GB fas powered	100 MB fast powered
Durability	For long-term use, reliability and durability	Very durable, durability cost	Very basid

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X. RESULTS AND DISCUSSION

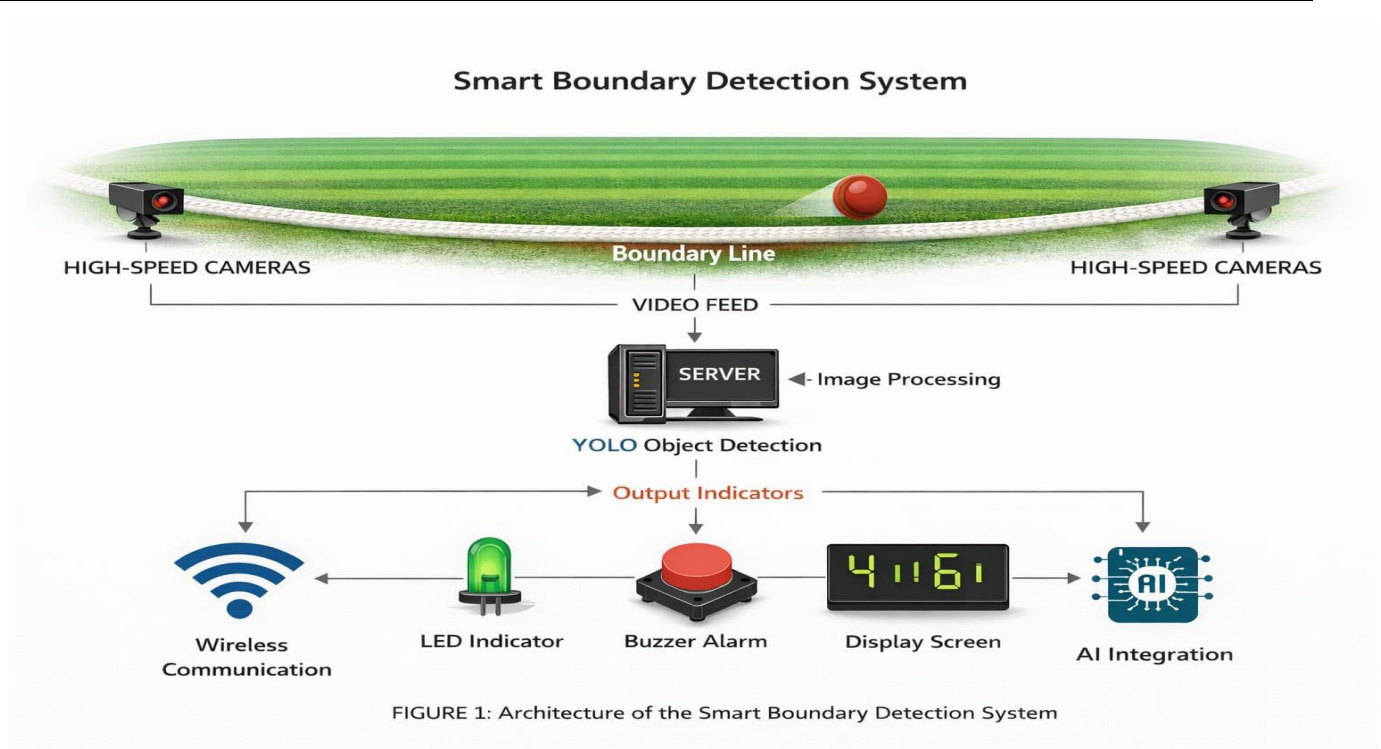
The proposed system is designed to provide accurate and fast boundary detection. Compared to traditional methods, the system reduces the time required for decision-making and improves accuracy.

The expected results of the system include:

- Immediate detection of boundary crossing
- High accuracy in real-time conditions
- Reliable performance in different lighting conditions
- Reduced dependency on human observation

The system can be tested in different environments such as playgrounds, stadiums, and practice fields. The performance of the system depends on the placement of sensors and the programming logic of the microcontroller.

During testing, the sensors successfully detected the movement of the ball across the boundary line. The microcontroller processed the signal and activated the output device instantly. This shows that the system can be effectively used in real-time cricket matches.



XI. ADVANTAGES

The proposed Smart Boundary Detection System offers several advantages:

- * Improves the accuracy of boundary decisions
- * Reduces human errors
- * Provides faster decision-making
- * Cost-effective solution
- * Easy to install and maintain
- * Suitable for small stadiums and local matches
- * Works in real-time conditions
- * Can be easily upgraded in the future

This system is especially useful for school-level and college-level cricket matches where expensive camera-based systems are not available.

XII. FUTURE SCOPE

The proposed system can be further improved by adding advanced technologies. In the future, the system can be integrated with Artificial Intelligence and Machine Learning to improve accuracy and prediction. Wireless communication modules such as Wi-Fi or Bluetooth can also be added to send data to a central system.

The system can also be connected to a mobile application to display real-time boundary results. Another improvement can include using multiple sensors to increase accuracy. Advanced display systems can also be used to show the result on a digital scoreboard.

In the future, this technology can be extended to other sports such as football, tennis, and hockey where boundary detection is important.

XIII. CONCLUSION

The Smart Boundary Detection System using sensor-based technology provides an efficient and reliable solution for automatic boundary detection in cricket. Traditional boundary detection methods depend on human observation, which may lead to errors. The proposed system uses sensors and microcontrollers to detect boundary crossing in real time.

The system is simple, affordable, and easy to implement. It improves accuracy, reduces human errors, and provides faster decision-making. The proposed system can be used in both professional and local cricket matches. This research contributes to the development of smart sports technology and demonstrates how automation can improve fairness in the game of cricket.

XIV. ACKNOWLEDGMENT

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