Design Woodball Line Detection and Monitoring System: A Preliminary Study

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Abstract: This paper entails the incorporation of electronics in the sports of woodball. The decisions made by the referees in most sports nowadays are with the use of electronic technologies to assist them. For instance, the goal-line technology in football and the electronic line judge in tennis is some of the recent advances in electronic technologies that have revolutionized sports as we know it. The woodball line detection and monitoring system serves a similar purpose where it assists the referee in making decisions and modernize the sports of woodball. The current woodball sports depend entirely on referees to give out decisions. The line detection technology helps to notify the referee if the woodball is Out of Bounds (OB) whereas the monitoring system notifies the player, referee and the audience whether the gating is successful or not. However, manual assistance from the referee is still needed for starting the play after a successful gating because the player is not allowed to touch the woodball during the entire game.

1. Introduction

The line detection system is widely used in the sector of sports in recent years [1–3]. The line detection system is a method in which the work involved in detecting the object is done by the sensors placed. For instance, the goal-line technology in football [4] and the electronic line judge in tennis [5] are some of the recent advances in electronic technologies that have revolutionized sports. The woodball line detection and monitoring system serves a similar purpose where it helps the referee in making decisions and modernize the sports of woodball. The current woodball sports depend entirely on referees to give out decisions. The line detection technology helps to notify the referee if the ball is Out of Bounds (OB) whereas the
monitoring system notifies the player, referee and the audience whether the gating is successful or not [6].

The recent advancement in sports technology has helped to modernize and computerize the game and changed the way of playing. These advancements in sports technology have been the initial reason for this paper. The paper proposes a framework of the automatic line detection of a woodball pitch. The line detection and monitoring system in woodball will reduce the job of the referee as it can detect an OB woodball and monitor the gating [7]. The referee might not get a clear view of the gating, as the standard length of a woodball pitch is from 30 to 130m. This lengthy pitch size will make it harder for the referee to get a clear view of whether the gating is successful or not to give out points. Moreover, the player also might not get a clear view of the gating and it may cause the unfair judgment of the referee which end up giving biased judgment in favour of the opposing player. Hence, the monitoring system uses LED to indicate a successful gating. If the woodball passes through the gate, the green LED will turn on, whereas if the woodball fails to pass through the LCD, it will not show the score of the player. In addition, LCD panel is also used for the monitoring of the results.

2. Literature Review
In 2018, Woosuk and Myunggu [8] proposed a method of using a wearable sensor for on-line detection and segmentation in sports. In their research, they used a standard wearable sensor to gather motion data. The sensor comprised of a tri-hub accelerometer, a tri-pivot gyrator and a tri-hub magnetometer. The sensor also had a 2.4 GHz wireless communication module. Furthermore, two high-speed cameras were used to record the motion from the side and top view. The data for soccer kicking and two hand ball-throwing are shown. Figure 1 below shows the wearable sensor used (a), the sensor worn on the ankle for soccer kicking (b) and the sensor on the wrist for two-handed ball throwing. Figure 2 below shows the high-speed cameras used to capture the images; the side camera (a) and the top camera (b).
A review of camera position estimation based on the volleyball court view in real-time was studied by Bolewicki and Kurowski [9]. Their work supports the referee in making decisions during the game. For instance, team sports such as volleyball must have an advanced tracking system that does not interfere with the player’s movement during the game. In this article, they used a 12-camera for intrinsic and extrinsic calibration of the referee system. The camera pinhole model is used to calculate intrinsic data together with Zhang’s method. The extrinsic calibration is performed and the 12 cameras are adjusted in a typical facilitate framework. Finally, the ball’s motion trajectory can be estimated using the 2-D image together with the 3-D real ball position coordinates. In a different study, Shouzhong Zhang presented his research on the effective field line detection and tracking in soccer videos [10]. In his article, he also showed how colour plays a part line detection. The lines on a football pitch are mostly white as it follows the rules of FIFA. However, with recent development in soccer, technology the modern field contains other types of field lines [11–13]. The offside lines are used by the referees to pass judgment on the offside. Those lines are not set apart in white shading, however, framed with turfing strategies. They are trimmed in such a way so that from others’ perspective outwardly one region is dim green and the other is light green. This helps the referee to distinguish the area of play and to give out offside decisions on the exact moment. The above findings contradict the study by Kolbinger and Linke. They presented on a cost-benefit-analysis of goal-line technology in soccer and thoughts about an introduction of video proof [14]. Recently, FIFA has introduced two different technologies, namely the goal-line technology that uses the Hawk - Eye system and the use of high-speed cameras. The high-speed cameras are placed around the pitch area so it can capture the ball’s position at all times. For example, the use of cameras in the German Football League has increased from 7 to 22. Furthermore, the Hawk-Eye system that is currently used in the English Premier League works together with the high-speed cameras to notify the referee.

With the same objective, Song et al. [15] proposed research for lane detection and classification for a forward-collision warning system based on stereo vision. They used a lightweight sound system vision-based driving path identification and grouping framework. For lane detection, they changed over the first RGB picture into a "log-chromaticity" space to direct street division. Furthermore, some different calculations were additionally applied to the path discovery in the first picture, for example, Hough Transform. Finally the lane changing is done after lane checking for cleared space. More recently, Michalopoulos et al. presented about using video-based technology in powerlifting to support referees’ decision making [16]. In this article, they proposed a model of the camera-based programming framework that comprised of three layers to be specific setup, motion-capture, and decision-making. The setup layer is answerable for gaining the biometrics information of the contending competitor. The precise acknowledgement of body joints and the proportion of the hip-to-knee, knee-to-lower leg, and lower leg to-foot separations play an important role in the motion capture layer. In the motion-capture layer, the development of the competitors while they play out a squat is caught. Next, the data is fed to the decision-making layer. The final layer calculates the relative distance of the body and the angle between body joints. Finally, if the separation estimated is more prominent than or equivalent to 0, at that point, the lift is viewed as a "decent lift"; else it is viewed as a "no lift".

3. Methodology

3.1 Design Stage

The design stage is the most important phase shown in figure 3. In this stage, the detailed explanation of the project design is explained. Next, the software used to design and simulate the design is also presented. Furthermore, the material selection for the design and the reasons for the selection are justified. Finally, the list of hardware used and the implementation process is drawn out.
3.2 Base Design
The real woodball game is played on a grass pitch measuring from 50 to 130m. The mini prototype of this paper is done using a base design that measures (80cm x 60cm x 1.5cm). The AutoCAD software is used to design the base for this paper. The dimension of the base is done at 80cm for length, 60cm for width and 1.5cm for height. Figure 4 below shows the designed base of the paper.

**Figure 3:** Flow of process of the paper design phase.

| Software Used          |            |
|------------------------|------------|
| Base Design            | Gate Design|

| Material And Hardware Selection |
|---------------------------------|
| Gate And Base                   | Line Detection And Monitoring System |

| Hardware Construction          |
|---------------------------------|
| Line Detection                  | Monitoring System |

**Figure 4:** Base Design
3.3 Gate Design
The gate serves the purpose of counting the score of the players after a successful gating when playing woodball. The design for the gate is also done using the AutoCAD Software as shown in Figure 6 and Figure 7. The dimensions used for the gate design are almost similar to the actual gate size used in the game. Figure 5 shows the actual size of the gate used in woodball allowed by the International Woodball Federation.

Figure 5: Actual Gate Dimension

Figure 6: Actual Dimension of Gate Cup  Figure 7: Gate Design
3.4 Model Design of Mini Prototype

The whole model design for the Mini Prototype Woodball pitch is shown in figure 8.

![Figure 8: Design of Mini Prototype](image)

3.5 Material Selection

This part focuses on the selection of materials used and the reason for it to be used to build the mini prototype.

3.6 Gate

The gate is built using a wooden cylinder block for the two gate bottles at the sides. The centre part (gate cup) is also built using wood. The gate cup is built in a way that it rotates when the woodball hits it at a given velocity. Furthermore, all three of these components are held together by a metal rod at the top. Finally, the materials used are almost similar to the real gate used in the real game. This is because using wood has its advantages such as it is more durable and has a heavier mass that does not topple when hit.

3.7 Base

The base encompasses a total of two layers. The bottom layer consists of an acrylic sheet. The top layer consists of a layer of fake artificial grass to simulate the woodball pitch to a certain extent. The height of the base is set at 1.5 cm approximately because the artificial grass is 0.5cm in height and the acrylic sheet is 1cm in height.

3.8 Hardware Selection

This part focuses on the hardware selection for the mini prototype woodball pitch. The hardware selection is made after thorough research on the paper and its requirements for it to achieve the stated objectives. The selection of materials might affect the result of the paper drastically. Therefore, the selection of materials is one of the most important things to consider.

3.9 Arduino UNO

The Arduino UNO microcontroller is used as the brain that controls the entire operations as shown in Figure 9. The Arduino UNO can follow the instructions from the user for the required operation. The reason for using the Arduino UNO is that it is low priced, easy to program and has extensible hardware and software.
3.10 Infrared Sensor (IR)

The use of IR (Infrared) Sensor is for the line detection system for the OB woodball to be notified. The selection of the IR sensor is because it is cheap and easy to install. The IR sensor has a transmitter and a receiver that send a signal and receives them back.

3.11 Liquid-Crystal Display (LCD)

The monitoring system is displayed via the use of the Liquid-Crystal Display (LCD). The LCD shows the gating result whether the ball passed through the gate or not and it displays the score of the player.

3.12 Light-Emitting Diode (LED)

The monitoring system is also aided by the use of Light-Emitting Diode (LED). The installed LED shows the result of gating. The Red LED lights up when the ball goes OB. The Green LED lights up when the ball successfully passes the gate.
4. Results And Discussion

4.1 Circuit Simulation

Figure 10: Circuit Simulation

Figure 10 shows the inputs and outputs used to notify the results for line detection and monitoring system. The LCD will show “System Ready” once the system is turned on.

4.2 Line Detection

The simulation results for the line detection are shown with the use of the IR sensor and the LEDs in the circuit. In the prototype, once the woodball passes through the IR sensors placed at the side, the Red LED will light up to indicate that the woodball is OB. The circuit simulation shows the same result.
Figure 11 illustrates the simulation done for the line detection system for woodball. The IR sensor (IR2) is turned on and the Red LED also turn on. This indicates that once the woodball passes through the IR sensor, detects the movement of the woodball and turns on the Red LED and indicates the ball which is OB. Moreover, if the ball does not go OB, the Red LED will not light up thus notifying that it is still in play.

4.3 Monitoring System
The simulation results for the monitoring system are shown with the use of the LCD and the Green LED. The LCD will display the gating result of the player whether he successfully scores the woodball passes through the gate.
Figure 12 shows the simulation results for a monitoring system for the woodball paper. Firstly, the IR sensor placed at the gate (IR1) will detect the ball movement that passes through the gate. Once the sensor detects the ball passing through the gate, it sends a signal to the LCD and shows the score of the player and the Green LED lights up. On the other hand, if the ball does not pass through the gate the sensor does not detect the ball movement and the score will not be shown and the Green LED will not turn on indicating a failed gating. Finally, the LCD will also show the gating result if the player scores consecutively. Table 1 shows the LCD for each consecutive gating performed successfully.

| No Of Gating | Gating Result | Player Score On LCD Display |
|--------------|---------------|-----------------------------|
| 1st          | Successful    | Score: 1                    |
| 2nd          | Successful    | Score: 2                    |
| 3rd          | Successful    | Score: 3                    |

The results above are only focused on using software based on circuit simulation. The circuit clearly shows the inputs used for detecting woodball and the outputs used to display the results and notifying the referee for easier decision making.
5. Conclusion
The woodball line detection and monitoring system mainly focus on its two major requirements for the paper which are as per stated in the title, the line detection for OB woodball and monitoring system for the gating result and to display the player’s score. Firstly, the prototype for the paper is designed using AutoCAD software. Moreover, the design of the gate is done following the rules and regulations stated by the International Woodball Federation. Next, the line detection and monitoring system are designed using IR sensors, Arduino UNO, LCD and LED as its main components. Furthermore, the simulation is done from software alone using Proteus Design Suite and the simulation results are shown clearly in the previous chapter. Finally, when the design for the prototype woodball pitch is completed, one of the objectives of the paper is achieved. The scope of this paper is aimed to be a miniature design for a woodball pitch compared to the real one used in the games. This paper is done based on the requirements of the paper and to achieve the stated objectives without any mishaps. Lastly, the monitoring system can be done using a much larger LCD to display the score if the player successfully gates the woodball. For the paper to be used on a larger scale, the line detection and monitoring system can be done on a wireless connection. This feature will surely help the game officials to give out unbiased decisions and also notify the audiences of the score. The recommendation for the paper in the future is that it can be done on a much larger scale so that it can be used in the real-life game where players can experience the line detection and monitoring system firsthand.

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