The 2014 conference of the International Sports Engineering Association

A modern approach to determine the offside law in international football

Alexander Henderson[a*], Daniel Lai[a], Tom Allen[b]

[a]Victoria University, Ballarat Road, Footscray, 3011, Australia
[b]Sheffield Hallam University, Sheffield, S10 2BP, UK

Abstract

The outcome of football matches is heavily dependent on referee decisions regarding violations of the offside rule. Football players should decide the outcome of the game rather than the referees. Instead of technology discrediting the ability of referees it should be adopted into the game to increase the accuracy of the offside decision. A system has been proposed that uses player tracking technology to quantify players' positions and runs an algorithm to determine which players are offside. The likelihood of algorithm error is dependent on the accuracy of player tracking technology. It was found that algorithm accuracy is improved by increasing the sampling rate and precision of player tracking technologies. The most suitable technology form for use in the proposed system is camera based player tracking. No device is required to be worn by players and body segment positions can be determined to ensure the offside law is completely adhered to. Before this proposed system could fully function a series of improvements must be made to the proof of concept model.

1. Introduction

Offside is one of the most critical decisions football referees make during the match. Attacking players who are involved in the offside decision are often part of a goal scoring opportunity. The offside law is specified by FIFA. The law states that if a player is in an offside position when the ball is played by a teammate, he/she may not become actively involved in the play. An offside position is taken when the player is nearer to the goal line than

---

• Alexander Henderson. Tel.: +61-4-0807-5266 ; fax: +61-3-9919-4908.
  Email address: Alexander.henderson@live.vu.edu.au

both the ball and the second to last member of the defensive team. The preceding statement only applies when in the opposition half of the field. FIFA (2013) states that being "nearer to an opponents' goal line" refers to "any part of the player's head, body or feet", however the "arms are not included in the definition." To become actively involved a player can touch the ball, obstruct opponents, intrude opponents' line of vision or gain advantage from being in the offside position. Advantage can be gained if the ball rebounds off the goal frame or a player (FIFA, 2013).

Previous studies have revealed failure rates for offside decisions of 12% at the 2009 Confederation Cup, Mallo et al. (2012), 10% at the 2006 World Cup and 26% at the 2002 World Cup, Catteeuw et al. (2010b). Debate occurs whether technology should be used to assist referees in their decision making process. As of the 2013/14 season the English Premier League will implement goal line technology to ascertain whether the ball has fully crossed the goal line. This decision proves that governing bodies believe technology can be used to enhance game officiating. This shift is vital to the perception of referee integrity.

Video replay technology has long been used to verify the calls and performance of referees. Rather than shame referee capabilities, video replay technology has been suggested to aid the offside decision process. This method dictates a time delay before the decision is made. Players, fans and FIFA oppose time delays. To overcome these issues a new system has been developed to enhance the offside decision process.

Player tracking technology has vastly improved analysis of players' physical capabilities as well as technical data relating to tactical positioning. Camera tracking, GPS and radio frequency (RF) methods are used to ascertain player positions. Camera tracking involves complex algorithms deciphering visual information to identify where players are on the field. GPS units are traditionally located on players' chest or neck and use triangulation methods from satellites to locate players. RF systems use a signal strength analysis tool to measure the distance a player's beacon is away from fixed points around the stadium. These reference positions allow players' positions to be identified on the field by triangulating the distance from each fixed marker. The proposed system will utilize these quantified player positions to determine offside.

2. The System

2.1. Hardware

A prototype watch been developed to prove the systems concept. It houses: a lithium ion battery, Xbee wireless transceiver, LCD display and two buttons to select the team in question. The Xbee module is configured in transparent mode to allow any wireless data packet received to be directly transferred to the serial LCD monitor. Another Xbee is located in the 'base station' on the side of the field. Here a computer is fed with the wireless Xbee data as well as player positions. Team selection is achieved by pressing one of two buttons located on the watch's top surface. These buttons determine the states of two Xbee pins. The corresponding pins of the Xbee located on the sideline are directly governed by the state of the watch's Xbee pins in a configuration known as I/O line passing. When a button is pressed on the watch the base station can immediately begin to run the algorithm.

2.2. The Algorithm

To determine which players are offside at a given time an algorithm is run to firstly find the second last defender and then compare every player from the attacking team against this reference. Players are identified by their jersey numbers and by their team. The reference is created using a bubble method in which the largest of a series of values rises to the top. The second largest is then taken for comparison. Each player from the attacking team is compared against the defending team's reference. Those players who exceed the reference position have their jersey number added to an array. Once all players have been compared, the jersey numbers of offside players are sent as a wireless data packet back to the referee's watch to be displayed on the LCD monitor.