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JOSHUA AFOLAYAN

HC20200104529

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SUBMITTED TO:

MR. FASHORO AYODEJI

DEPARTMENT OF COMPUTER SCIENCE

SCHOOL OF APPLIED SCIENCES

FEDERAL POLYTECHNIC EDE, OSUN STATE, NIGERIA.

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**ABSTRACT**

This report will examine technology’s influence throughout the sporting world and its current paramountcy on sporting matches and events. It will analyze current technological officiating methods concentrating on their level of success and how these could be imitated in football; using valued perspectives both for and against technological involvement in football. The paper will acknowledge each side of the argument in detail, deciphering factors that cause such strong opinions to be held around the debate of goal line technology or indeed the lack of it. The opinions of those whom are involved and will be effected by such a change in the world’s most popular game will be discussed in conjunction with the vast list of questions and issues surrounding the debate.

Factors involving the various technologies available or in current development will be discussed as well as the way the politics, that have many believing are the sole source of football’s lack of technological input, effect companies’ and institute’s researching and developing of potential goal line technology. The head of the University of Loughborough's sporting development institute, Professor Mike Caine will speak of his personal stance on all of the controversy that has ignited the deliberation of the goal line technology debate in a phone interview conducted at the culmination of this dissertation.

The dissertation will conclude in successfully arguing for the implementation of goal line technology into the sport of football via video replay.

1.0 INTRODUCTION

The topic discussed in this research is the emergence of the use of video technology in sports in recent years. During our lifetimes, information and computer technologies have significantly changed the world. The major technological revolution has had a very profound effect on contemporary sports over the last twenty years. Therefore, the use of different types of technology has become important in recent years due to the fact that sports contain moments in which there are mistakes made by referees and officials. The introduction of technology regarding these sports in recent years has helped to eradicate a number of these errors. The specific type of technology that is going to be discussed in this research paper is the use of video technology in relation to the potential introduction of goal line technology in football. With implanted chip, part of proposed Cairos-Adidas system for Goal-line technology On 5 July 2012, the International Football Association Board (IFAB) officially approved the use of goal line. The two systems approved in principle were involved in test phase 2: GoalRef and Hawk-Eye. In December 2012, FIFA announced it would introduce goalline technology in a competitive match for the first time at the 2014 FIFA World Cup in Brazil.

**LITERATURE REVIEW**

2.0 INTRODUCTION

It has come into the spotlight because of recent incidents where in games, the ball has crossed the line, but has not been noticed by the referee, and so the goal was not given. Sometimes when the ball crosses the line by a couple of inches before being hoofed out by a defender, it is difficult for the ref to see.

As the drone of the vuvuzela faded and the world recovered from the 2010 FIFA World Cup extravaganza in South Africa, one issue that will be on the lips of many a football fan around the world is whether goal-line technology has a place in the “beautiful game”. England player Frank Lampard’s disallowed goal against Germany in Bloemfontein on June 28, 2010 and various other controversial refereeing decisions at the FIFA 2010 World Cup fueled a long-standing debate about whether to introduce technology that can determine when a ball has crossed the goal line. The question officials had to answer, especially when a ball hits the cross bar and bounces down, is on which side of the line did the ball land?

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Technology is now widely used to support umpiring and refereeing decisions in a range of sports. In tennis, it is commonly used to verify line calls, in cricket to back-up leg-before-wicket (LBW) decisions and in rugby to verify tries.

FIFA, the world’s football governing body, resisted the introduction of goal-line technology for some years. In March 2010, the International Football Association Board (IFAB), responsible for establishing the laws of the game, voted not to use the technology as they felt it was not good for the game. Following a number of controversial refereeing decisions at the 2010 FIFA World Cup, however, FIFA agreed to revisit the issue. Just days before the end of the tournament, FIFA General Secretary Jerome Valcke said, “I would say that it is the final World Cup with the current refereeing system.” He added, “The game is so fast, the ball is flying so quickly, we have to help them (the referees).”

Goal-line incidents have been the subject of great controversy and debate for many years. The most famous goal-line decision concerned the third goal scored by England (Geoff Hurst) in the 1966 World Cup final against West Germany. While 44 years ago the technologies available were limited, today the technological landscape is vastly different offering a range of possibilities that can assist referees in their decisions.

3.0 **METHODOLOGY**

The two main candidate technologies for use in football are those produced by U.K. Company, Hawk-Eye Innovations and German company Cairos Technologies AG. Other two supporting technologies are the Goal Control 4D and GoalRef. These technologies can divided into two namely camera tracking and magnetic field tracking.

**3.1 Camera Tracking**

3.1.1 Hawk-Eye: Tracking balls in flight

The Hawk Eye technology is the most high-profile system amongst these varying technologies. It uses fourteen sophisticated cameras placed around the stadium at different positions pointing towards the two firm goal posts, seven focused on each. This technology isn’t something novel, and has been widely used in other sports for more than a decade, most noticeably in cricket, tennis and snooker. The high-speed cameras track the ball with high accuracy and use triangulation to calculate its precise position relative to the goal line.

Triangulation is a geometric technique of calculating the distance and position to and of, respectively, an unknown point with the help of two known points. As the name suggests, the system forms triangles between these three points and uses the angles between them to determine the whereabouts of the third unknown. The system software then creates a 3D image of the ball relative to the line.

This technology can produce reliable results even when the view of some cameras is obstructed by players’ bodies. This is because only three of them are required to implement triangulation and generate an image. Therefore, even if the view of a few cameras is hindered, the others can take over seamlessly. The software calculates the ball’s location in each frame by identifying the pixels that correspond to the ball. A better perspective of how meticulously competent these cameras are can be acquired when you consider that a kicked football flies through the air at an average of 120 km/hr. If the ball fullycrosses the goalmouth, an encrypted signal is transmitted to the referee via a watch or an earpiece within half of a second, alerting them to a goal. Whereas, the ball must fully cross the line for it to count as a goal.

Hawk eye cameras also allow for evaluating and simulating trajectories of an object if it had been allowed to continue its motion or if its motion hadn’t been interrupted by an obstacle. For instance, the simulated trajectory of a cricket ball can determine whether it would have hit the stumps had it not hit the batsman first.

This Hawk eye system was first featured in the 2013-2014 Premier League in the U.K. Since then, it has also been adopted by the other Ivy leagues of football: Bundesliga, La Liga and Serie-A. Images are processed by a bank of computers in real time and sent to a central computer programmed to analyze a predefined playing area according to the rules of the game. This information is used to determine whether a ball has crossed a line or other rules have been infringed. In each frame sent from each camera, the system identifies the cluster of pixels that corresponds to the image of the ball. It calculates for each frame the three-dimensional position of the ball by comparing its position at the same instant in time on a least two cameras placed in different locations. A succession of frames builds up a record of the path along which the ball has travelled. The system generates a graphic image of the ball’s path and the playing area in real time and this information is readily available to judges, television viewers and coaching staff.

The system is even more astute than regular TV replays. A ball travelling at 60mph (97kph) moves at one meter per video frame on standard broadcast cameras which operate at 25 frames per second. Hawk-Eye uses cameras that operate at 500 frames per second making it possible to detect if a ball has crossed the goal line even for a fraction of a second.

The Hawk-Eye brand and simulation has been licensed to Codemasters, one of the oldest British video game developers, for use in sports video games and consoles.

Hawk-Eye was first used by U.K. broadcaster, Channel 4 during a Cricket Test Match between England and Pakistan on Lord’s Cricket Ground in May 2001. It is now regularly used by network broadcasters in many high-profile sporting events.

The International Cricket Council (ICC), the international governing body of cricket, first trialed Hawk-Eye in the 2008/2009 winter season to verify controversial LBW decisions. The umpire was able to look at what the ball actually did up to the point at which it hit the batsman but could not look at the predicted flight of the ball thereafter.

“As a player, and now as a TV commentator, I always dreamed of the day when technology would take the accuracy of line calling to the next level. That day has now arrived.” Pam Shriver (TV commentator and former elite tennis player)

In the football stadium, Hawk-Eye’s development began in earnest in 2006 with trials first at Fulham Football Club (FC) and then at Reading FC. The system has been independently tested by the English Premier League and IFAB. The latter had stipulated that the technology must be accurate to within 5mm and provide the required information to the referee in less than 0.5 seconds. Hawk-Eye meets each of these conditions.

3.1.2 Goal Control 4-D

Similar to the Hawk Eye technology, Goal Control 4-D uses 14 high-speed cameras installed around the stadium pointing at the goalposts. Seven cameras are dedicated to each frame. They calculate the ball’s position and trajectory to eliminate the ambiguity regarding the ball crossing the goal line. One major limitation of this system is the high cost of implementation. Even though it was used in the 2014 World Cup, it was dismissed by the top-flight leagues due to its higher cost.

The GoalControl-4D technology boasts a precision 5 mm above the specifications defined by FIFA. The soccer referee is immediately informed. A watch attached to the system vibrates and displays « Goal » when a goal is scored. France will remain in the history of the World Cup in Brazil after the first goal allowed by this technology on the goal line. It was June 15, 2014 in Porto Alegre. A shot from Karim Benzema who hit the post before returning to the guard just above the line… In the end, Goal-line technology validates the goal for Honduras against his camp.

**3.2 Magnetic Field Tracking**

**3.2.1 The Cairos System – A microchip in a match ball**

Produced by the German technology giant Cairos Technologies AG, partnering with Adidas, this technology uses a magnetic field to track a ball, inside of which is a suspended electronic sensor. Thin wires carrying electric current are buried around the penalty area and behind the goal line to form a grid. Adidas specially designed a ball that could not only suspend a delicate sensor inside it, but also withstand vigorous kicks without suffering any harm.

A moving ball impacts the uniform magnetic field due to the interference between copper wires and the magnetic field. The ripple is transmitted through the grid to a computer, which decides whether the ball crossed the line or not. A confirmed break in is instantaneously followed by a goal alert on the ref’s watch. However, there have been doubts over the accuracy of its results and speed. The Cairos system involves embedding thin cables in the turf of the penalty area and behind the goal line. The electrical current that runs through the cables generates a magnetic field.

A sensor suspended in the ball measures the magnetic fields as soon as the ball comes into contact with them and transmits data about the ball’s location to receivers located behind the goal that relay the data to a central computer. The computer then determines whether the ball has crossed the goal line. If so, a radio signal is transmitted to the referee’s watch within a split second.

Development began in 2006 and was first tested at the 2007 FIFA Club World Cup™ in Japan where it performed perfectly. At that time, Cairos teamed up with Adidas who “developed the suspension system for the ball, so that it keeps our chip safe inside the ball even when you kick the ball very hard,” said Oliver Braun, Cairos’ Director of Marketing and Communications. Adidas produced the test balls and those used during the FIFA Club World Cup in Japan. One of the main concerns of those against using the new technologies is that of cost. They believe the costs of installation would be prohibitive and would create a two-tier system in football. Mr. Braun, however, explained that “Cairos bears the costs for the installation and will only charge the associations a percentage of what they pay the four referees for a match.” As for Hawk-Eye, Dr. Hawkins, told Press Association Sport that his company would install its goal-line technology in every Premier League ground free of charge in return for rights to sell sponsorship around the system.

3.2.2 GoalRef

This technology also uses a passive electronic circuit implanted in the ball that excites a low-frequency magnetic field covering the entire goalmouth as the ball whizzes past it. The electronic circuit is composed of three copper coils in a bunch that is attached between the bladder and surface panel. The antennas generating this magnetic field are mounted on the crossbar and parallel goalposts. Again, as soon as the ball crosses the line, the antennas sense a change in their magnetic fields and relay the data to a computer, which decides whether the ball has crossed the line or not. If it has, an alert signaling a goal is transmitted to the referee within half a second. The 2012 Club World Cup was the first tournament to implement this technology.

Despite their assistance, Goal-Line Technologies are still frowned upon in some circles. This disdain is partly due to the imminent erosion of the human element, and partly because the results are sometimes confusing or nonsensical. For example, in the game between France and Honduras during the 2014 World Cup, a goal signal was alerted, even though the ball didn’t fully cross the line. This caused a lot of confusion amongst coaches and commentators who were watching the replays.

Recently, a few leagues have taken a further step and recruited review systems that allow a referee to look back at his previous decisions. This could allow him to actually fix his mistakes or ask for help when in doubt, even though it might slow down the game’s pace. These sort of halts in a fast-moving game has bothered fans and players equally. The new technology promises to remove the slightest of human biases and with them, the errors imposed by far away, unsighted refereeing. However, at the same time, it transitions the sport to an impassive computer-judged activity.

3.3 CHALLENGES

There are a few challenges that have been identified with the use of goal line technology in soccer:

1. **Cost**: Implementing goal line technology can be expensive, particularly for smaller clubs or leagues that may not have the financial resources to do so.
2. **Complexity**: The technology required to accurately detect whether the ball has crossed the goal line can be complex, and there is a risk of technical issues or malfunctions.
3. **Human** **error**: While goal line technology is designed to be accurate, there is still a risk of human error in the operation and maintenance of the system.
4. **Acceptance**: Some soccer fans and officials may be resistant to the use of technology in the sport, believing it takes away from the human element of the game.
5. **Consistency**: Ensuring that the technology is consistently and accurately used across all matches and leagues can be a challenge.

**3**.4 RECOMMENDATION

It is ultimately up to individual soccer leagues and organizations to decide whether to implement goal line technology. However, some possible recommendations for the use of goal line technology in soccer could include:

1. Ensuring that the technology is reliable and accurate: It is important that the goal line technology chosen is proven to be reliable and accurate, in order to minimize the risk of errors or technical issues.
2. Providing adequate training and support for those using the technology: It is important that those responsible for operating the goal line technology are properly trained and have access to the necessary support to ensure that it is used correctly.
3. Ensuring that the technology is consistently used across all matches and leagues: In order to maintain the integrity of the game, it is important that the technology is consistently used in all matches and leagues.
4. Communicating the benefits of the technology to fans and officials: It can be helpful to communicate the benefits of goal line technology to fans and officials, such as the increased accuracy and fairness it brings to the game.
5. Ensuring that the cost of implementing the technology is reasonable: It is important to consider the cost of implementing goal line technology, and ensure that it is reasonable and feasible for the organizations involved.

4.0 **CONCLUSION**

First implemented at FIFA Club world cup 2012, and since then it has been implemented at multiple tournaments, like English Premier League, Liga BBVA, Bundesliga, etc and internationally it has been implemented at FIFA Confederations Cup 2013 and the FIFA world cup 2014, both in Brazil. GLT has been a success, since it has ameliorated the sport and given a helping hand to the match officials. Goal Line Technology makes use of GoalMinder, Cairos , GoalRef and the Hawk-eye system to assist in decision making. It has eliminated the missed events affecting the game as well as it uses magnetic fields and cameras to enhance the decision making ability of the referees.

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