

## Hawk-Eye and Goalline Technology

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**Abstract-** This paper depicts the usage of Hawk Eye Technology. HawkEyeTechnology is a mind boggling PC framework utilized as a part of cricket, tennis, football and different games to outwardly track the way of the ball and show a record of its most factually likely way as a moving picture. It is likewise utilized as a part of a few cases to foresee the future way of a ball in cricket and in addition in football. The HawkEye is one such innovation which is thought to be truly first class in games. The fundamental thought is to screen the direction of the ball amid the whole span of play. This information is then prepared to create life like representations demonstrating the ways which the ball took. Such information has been utilized for different purposes, prominent utilizations including the LBW choice and in football to see whether the ball has gone too far, making programming and vivid wagon wheels indicating different measurements. The goal-line innovation is a technique used to decide when the ball has somewhat crossed the goal line with the help of electronic gadgets and in the meantime helping the official in recompensing a goal or not. Point of goal-line innovation is to help the match authorities in choice making as opposed to supplanting them.

**Keywords:** Hawk Eye, Goal Line, Sports, FIFA 2012, Implementation, GLT, GOALREF

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### I. INTRODUCTION

Hawk Eye has demonstrated a standout amongst the best and imaginative advancements in the wearing history, with most eminent games, for example, Tennis and Cricket actualizing the framework. It was created by the designers of Roke Manor Research Limited in 2001. This innovation was made by Dr. Paul Hawkins, who designed the ball following framework to enhance the nature of donning choices, giving a brisk, dependable and precise framework which could bolster coordinate authorities when settling on indispensable choices in genuine diversion circumstances. This innovation was utilized first amid test match between Pakistan and England on 21st May. It is a suite of rapid cameras and programming used to track a ball's way. Hawk-Eye is most creative innovation in games television world is an advancement that will fortify the gathering's vicinity and impact. Make the diversion intriguing and reasonable. Amid our lifetimes, data and PC advances have fundamentally changed the world. The major mechanical transformation has had an extremely significant impact on contemporary games in the course of the most recent a quarter century. Consequently, the utilization of various sorts of innovation has ended up vital lately because of the way that games contain minutes in which there are missteps made by arbitrators and authorities. The presentation of innovation with respect to these games as of late has annihilated some of these blunders. The particular kind of innovation that will be talked about in this exploration paper is the utilization of

video innovation in connection to the potential presentation of objective line innovation in football.



**Fig 1** The Adidas Teamgeist – II with implanted chip, part of proposed Cairo-Adidas system for Goal-line technology

On 5 July 2012, the International Football Association Board (IFAB) officially approved the use of goal line technology. The two systems approved in principle were involved in test phase 2: GoalRef and Hawk-Eye. In December 2012, FIFA announced it would introduce goal-line technology in a competitive match for the first time at the 2014 FIFA World Cup in Brazil. [1][2]

### II. REVIEW

At its Annual Business Meeting on 20 October 2010, the IFAB discussed the implications of measurement systems that are capable of automatically detecting the scoring of a goal during a football match (so-called goal-line technology

or GLT). Consequently, the IFAB laid down a set of four basic requirements a GLT system has to fulfill: [2]

- The goal-line technology applies solely to the goal line and Test at the Home of FIFA in Zurich only to determine whether a goal has been scored or not.



**Fig 2** Test at the Home of FIFA in Zurich

- The GLT framework must be exact;
- The sign of whether an objective has been scored must be quick and naturally affirmed inside of one second.
- The sign of whether an objective has been scored will be imparted just to the match authorities (by means of the arbitrator's watch, by vibration and visual sign).

Similarly as with all progressions to the Laws of the Game, IFAB must endorse the utilization of objective line innovation. Six votes are required to roll out any improvements. FIFA holds four votes and each of the world's initial four football affiliations conveys one vote. These are England's The Football Association, the Scottish Football Association, the Football Association of Wales and Northern Ireland's Irish Football Association.

## 2.2 Challenges for the referee

One of the difficulties for refs is that the human eye can deal with just roughly 16 pictures for each second, which implies the ball should be behind the line for no less than 60 milliseconds. In any case, at times the ball is just behind the line for a couple of milliseconds before a player kicks it back or it bounce back once again into the field of play, with the outcome that the human eye can't see whether the ball has gone too far. [1][3]

Another test is the vantage point. At the point when seen from specific edges, it is anything but difficult to misconceive the ball's position. Cameras put at various edges can delude viewers when demonstrating pictures "demonstrating" regardless of whether the ball has gone too far, which is the reason just innovation committed to assessing such occurrences can bolster the ref in the choice making process and add to a reasonable amusement.[3]



**Fig 3** One situation, different perceptions

## III. PRE-PLANNING

As an initial step, the opposition coordinator ought to talk about the necessities and sentiments of the opposition individuals concerning objective line innovation. In the wake of performing a money saving advantage examination for this venture, it is prescribed that the coordinator talks about and answers essential inquiries on the execution of GLT for the opposition being referred to.

Steps included in pre-planning are:

- 1 – Cost Calculation
- 2 - Pre-planning checklist
- 3 - Recommended content of tender for GLT
- 4 – Recommended agenda for site inspection
- 5 – Bidding procedure checklist
- 6 – Project agreement – consideration of legal points.[1][2]

### 3.1 Hawk – Eye

The Hawk-Eye framework was initially created in 1999. It depends on the guideline of triangulation utilizing the visual

pictures and timing information gave by fast camcorders at various areas around the range of play. The framework utilizes high edge rate cameras to triangulate and track the ball in flight. The product computes the ball's area in every identifying so as to case the pixels that relate to the ball. The product can track the ball and foresee the flight way, regardless of the possibility that few cameras are being blocked. The framework likewise records the ball's flight way and stores it in a database that is utilized to make a realistic picture of the flight way, so the pictures can be appeared to analysts, mentors and groups of onlookers. The information from the framework can likewise be utilized to decide insights for players and investigate patterns. The proposition includes setting seven cameras for every objective mouth around the stadium.[4]

### 3.2 GoalRef Attachment

GoalRef highlights a uninvolved electronic circuit implanted in the ball and a low-recurrence attractive field around the objective. Any adjustment in the field on or behind the goal line is distinguished by loops installed in the objective edge, which decide the scoring of a goal. By delivering low attractive fields around the objectives, GoalRef makes what might as well be called a light drapery. When the ball has entirely crossed the objective line between the posts, an adjustment in the attractive field is identified. An objective caution is then momentarily transmitted to the amusement authorities utilizing a scrambled radio sign, with a message showed on their wristwatches.



Fig 4 GoalRef Attachment

There are few pros and cons of using this technology

The advantages are:-

Returns the signal in 1/10th of a second

Ball doesn't have to be visible

99.9% accurate

The only disadvantage here is that it is compatible only with Adidas balls.



Fig 5 Cairo's GLT system

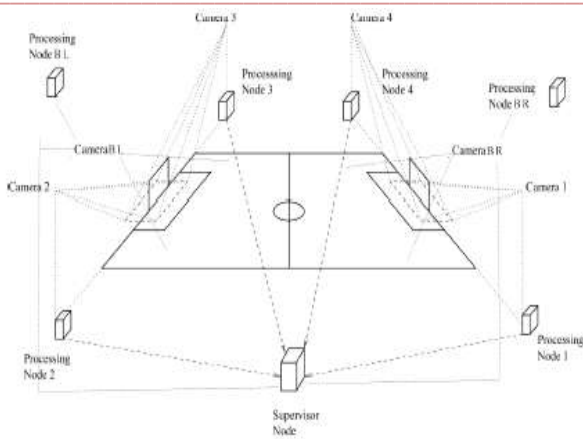
## IV. INSTALLATION PERIOD

A standout amongst the most delicate focuses amid this period of the task is deciding a joint timetable for the establishment and last test of the objective line innovation frameworks. All gatherings in this procedure (rivalry coordinator, GLT supplier, stadium administration) ought to along these lines concede to the dates when the organization will be permitted access to the stadium(s) to introduce its system(s), particularly those dates when it is permitted to enter the field of play.

## V. Overview of the System

Six cameras are put on the stands of the stadium. For every side of the pitch, two of the three cameras have their optical tomahawks parallel to the objective casing; the staying one is set behind the objective with its optical hub opposite to the objective outline. Every camera is associated with a processor (hub) that records and examines the procured pictures. A schematic graph of the handling steps executed by each hub is appeared. The six processors are associated with a primary hub, which has the manager capacity. The boss hub has a choice combining so as to make capacity the handling results originating from the cameras. The system depends on a few heuristics that perform information combination assessing the time space soundness of the ball's 3D direction. The handling results of the three relating hubs are looked at and an objective. [1] [2] [3]





## VI. BALL DETECTION AND TRACKING

A customized procedure that recognizes ball position in every photo is the central step to building the vision system. In the soccer world, an amazing number of issues must be administered, tallying obstacles, shadowing, mis-disclosure (the off course revelation of articles like the ball), and rearward regardless, not least, constant get ready restrictions. The ball revelation method must be to a great degree fundamental, snappy and convincing as an extraordinary number of pictures each second ought to be taken care of. This kind of issue can be tended to by considering two particular ID structures: geometric philosophies that can be associated with direction a model of the object of energy to different parts of the pictue in order to find the best fit; or case based techniques that can be associated with take in the exceptional segments of a class of things from sets of positive and negative outlines. This methodology uses two one of a kind techniques together as a piece of solicitation to abuse their qualities: in particular, a brisk circle ID (and/or circle bit acknowledgment) figuring, develop just as for edge information, is associated with the whole picture to restrict the photo zone to the best cheerful containing the ball; second, an appearance based partition measure is utilized to acknowledge ball hypothesis. The Circle Hough Transform (CHT) arrangements to find indirect case of a given compass R within a photo. Each edge point contributes a circle of breadth R to a yield gatherer space. The top in the yield gatherer space is recognized where these contributed drifts spread at the center of the principal circle. Remembering the final objective to diminish the computational inconvenience and the amount of false positives normal of the CHT, different modifications have been by and large realized in the latest decade. The use of edge presentation information compels the possible positions of the center for each edge point. Thusly only a bend inverse to the edge presentation at a partition R from the edge direct needs toward be plotted. The CHT, furthermore its modifications, can be figured as

convolutions associated with an edge degree picture (after reasonable edge ID). We have portrayed a circle distinguishing proof director that is associated over all the photo pixels, which makes a maximal worth when a circle is related to a compass in the range. [3]

$$u(x, y) = \frac{\int \int_{D(x,y)} \vec{e}(\alpha, \beta) \cdot \vec{O}(\alpha - x, \beta - y) d\alpha d\beta}{2\pi(R_{max} - R_{min})} \quad (1)$$

where the domain  $D(x,y)$  is defined as:

$$D(x, y) = \{(\alpha, \beta) \in \mathbb{R}^2 | R_{min}^2 \leq (\alpha - x)^2 + (\beta - y)^2 \leq R_{max}^2\} \quad (2)$$

$\vec{e}$  is the normalized gradient vector:

$$\vec{e}(x, y) = \left[ \frac{E_x(x, y)}{|E|}, \frac{E_y(x, y)}{|E|} \right]^T \quad (3)$$

and  $\vec{O}$  is the kernel vector

$$\vec{O}(x, y) = \left[ \frac{\cos(\tan^{-1}(y/x))}{\sqrt{x^2 + y^2}}, \frac{\sin(\tan^{-1}(y/x))}{\sqrt{x^2 + y^2}} \right]^T \quad (4)$$

The use of the normalized gradient vector in (1) is necessary in order to have an operator whose results are independent from the intensity of the gradient in each point: we want to be sure that the circle detected in the image is the most complete in terms of contours and not the most contrasted in the image. Indeed, it is possible that a circle that is not well contrasted in the image gives a convolution result lower than another object that is not exactly circular but has a greater gradient. The kernel vector contains a normalization factor (the division by the distance of each point from the centre of the kernel) which is fundamental to ensuring that we have the same values in the accumulation space when circles with different radii in the admissible range are found. Moreover, normalization ensures that the peak in the convolution result is obtained for the most complete circle and not for the greatest in the annulus. As a final consideration, in equation (1) the division by  $(2\pi \cdot (R_{max} - R_{min}))$  guarantees the final result of our operator in the range  $[-1, 1]$  regardless of the radius value considered in the procedure. The masks implementing the kernel vector have a dimension of  $(2 \cdot R_{max} + 1) \times (2 \cdot R_{max} + 1)$  and they represent the direction of the radial vector scaled by the distance from the centre in each point. The convolution between the gradient verso images and these masks evaluates how many points in the image have a gradient direction concordant with the gradient direction of a range of circles. Then the peak in the accumulator array provides the centre of the sub-image with higher circularity that is finally passed to the validation step.

Examples of sub-images given as input to the ball recognition process are shown in figure 3. [3]

## VII. FINAL INSTALLATION TEST AND ACCEPTANCE OF THE INSTALLATION

Checklist for final installation test and acceptance of the installation  
Select a free test foundation for the last establishment test (contract required)  
Decide a timetable for definite establishment test  
Set up the opposition stadiums (stadium administration) for the last test  
Affirm the last establishment in view of positive test outcomes  
Present the marked FIFA acknowledgment and affirmation structure to the GLT supplier  
Check whether the establishment shows up on fifa.com before the begin of the opposition.



**Fig 6**Final installation test – dropping a plumb to define the goal line.

Once the prerequisites for conclusive establishment test and Acknowledgment of the establishment are satisfied then the FIFA Quality Program for Goal Line Technology (GLT) hands out an affirmation to the affiliation. This is known as the FIFA acknowledgment and affirmation structure.

## VIII. EDUCATION OF REFEREES

Instructional course on Goal-Line Technology. Clear up why target line advancement supports refs (vantage centers!). Present the presented GLT structure. Demonstrate the precision of the structure. Elucidate the official's watch in unobtrusive component. Hand over an official motivation for the necessary ref check. Give get ready in the official check for each and every sharing ref Clarify the framework should the watch glitch in the midst of a match. Demand feedback on the handiness of the GLT system after each match Questions and answers after the instructional course.

"It was imperative that we had the instructional meeting before the competition to demonstrate the arbitrators the exactness of the framework and that they could depend on the new innovation."

(FIFA Head of Refereeing Massimo Busacca, 16 December 2012) [2]



**Fig 7** Goal-line technology training session  
IX. CRITICISM:

### a. Human Component is lost

While advocates for objective line innovation keep up that it would altogether lessen refereeing blunders amid play, there are likewise reactions of the innovation. A significant part of the feedback originates from inside FIFA itself including former FIFA president SeppBlatter. Aside from the reactions spinning around the specialized parts of the two proposed advancements, faultfinders call attention to that such innovation would affect on the human component of the diversion and evacuate the happiness regarding debating botches. SeppBlatter has been cited as saying "Different games routinely change the laws of the diversion to respond to the new innovation. ... We don't do it and this makes the interest and the fame of football".

A study recommended that in the 2010–11 Premier League season "blunders occurred almost 30% of the time that video replays could counteract", however a few individuals guarantee that moment replays would intrude on the stream of the diversion and take away conceivable plays.

Different commentators trust it would be restrictively costly to execute the innovation at all levels of the amusement and especially for littler/poorer football affiliations. FIFA

authorities have communicated an inclination for 'better refereeing' and in addition more match authorities over executing the technology. Advocates thusly refer to the numerous samples of mistaken objective line choices choosing essential recreations and point out that the innovation has enhanced much since the underlying trials completed by FIFA. Advocates fight that any additional help for the official ought to exceed contentions that it would prompt non-uniform tenets (since not all football affiliations would have the capacity to actualize it).

Blatter had been against objective line innovation until Frank Lampard's refused objective in the 2010 World Cup where the ball unmistakably went too far.

The presentation of the alleged "fifth authority", i.e. the additional right hand ref remaining adjacent to the objective line, was mostly to encourage in such circumstances.

#### b. Cost

In April 2013, MLS magistrate Don Garber affirmed that MLS would not receive objective line innovation for the 2014 season, referring to cost as the overriding variable. GoalControl installation would cost about \$260,000 per stadium, and a further \$3,900 for every amusement.

In mid 2014, by far most of groups in the two divisions of the German Bundesliga voted against presenting objective line innovation for monetary reasons. The expenses per club would have run from €250,000 for a chip inside the ball up to €500,000 for Hawk-Eye or Goal Control. The administrator of 1. FC Köln, JörgSchmadtke, outlined the vote with "The expense is exorbitant to the point, that utilizing this (innovation) is not acceptable" World representing body FIFA are set to make £300,000 from the Premier League's choice to introduce objective line innovation in all top-flight stadiums before the begin of next season. Each of the 20 clubs will need to pay FIFA £15,000 to introduce, test and get the 'FIFA quality seal' for Hawk-Eye's camera-based framework, which is relied upon to cost around £250,000 per ground altogether. FIFA will likewise make an additional £15,000 from Wembley Stadium, which will have the innovation introduced for use in occasions, for example, the FA Cup semi-finals and last.

1. Probably wouldn't be as great from a spectator's point of view

2. All balls would have to be manufactured with this chip

#### X. ENHANCEMENT

The one of the greatest improvement would be if the ball can be made without the chip.

The chip likely expands the heaviness of the ball which might influence the bend of the ball when a player shoots. The insertion of the chip in the ball additionally expands the expense of the innovation. Because of the high cost this innovation is yet to be actualized overall associations. Still objective line innovation is just utilized as a part of few groups because of its expense. Another zone of change should be possible in bird of prey eye. The establishment of six cameras on every side of the objective will mean the establishment expenses will be high. Consider the expenses if this somehow managed to be guaranteed for all football matches the world over. In spite of the fact that, the framework is equipped for reenacting the ball's direction inside of 1 second, it would really gobble up a great deal of time when appeared on replays. It requires the ball to be no less than 25% noticeable, or else we need to depend on the ref's judgment like old times.

#### XI. CONCLUSION

Initially executed at FIFA Club world cup 2012, and from that point forward it has been actualized at various competitions, similar to English Head Class, Liga BBVA, Bundesliga, and so forth and globally it has been actualized at FIFA Confederations Cup 2013 and the FIFA world cup 2014, both in Brazil. GLT has been a win, since it has improved the game and given some assistance to the match authorities. Objective Line Innovation makes utilization of GoalMinder, Cairo's ,GoalRef and the Hawk eye framework to help with choice making. It has dispensed with the missed occasions influencing the amusement and in addition it utilizes attractive fields and cameras to upgrade the choice making capacity of the arbitrators.

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