



HAWK-EYE TECHNOLOGY

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What is Hawk-Eye?

Hawk-Eye is a complex computer system used officially in numerous sports such as cricket, tennis, Gaelic football, badminton, hurling, and association football, to visually track the trajectory of the ball and display a record of its statistically most likely path as a moving image.



HISTORY

- Hawk-Eye was developed in the United Kingdom at Roke Manor Research Limited by Dr. Paul Hawkins. The system was originally implemented in 2001 for television purposes in cricket.
- Later, the technology was spun off into a separate company, Hawk-eye Innovations Ltd.
- The system was first used during a Test match between Pakistan and England at Lord's Cricket Ground , on 21 April 2001.
- It was first used in tennis 2006 US open.

Basic Components

- HAWKEYE system consists of two significant parts:-

i)Tracking System- It consists of :-
Camera and Speed gun

ii)Video Replay System

Tracking System

It calculates the following information:-

1. The speed of the ball leaving the bowler's hand.
2. The swing of the ball from the bowler's hand to where the ball pitched.
3. How much the ball bounced.
4. How much the ball deviated sideways off the wicket

HAWKEYE CAMERA

The camera record the movement of ball at the rate of 100 frames per second.



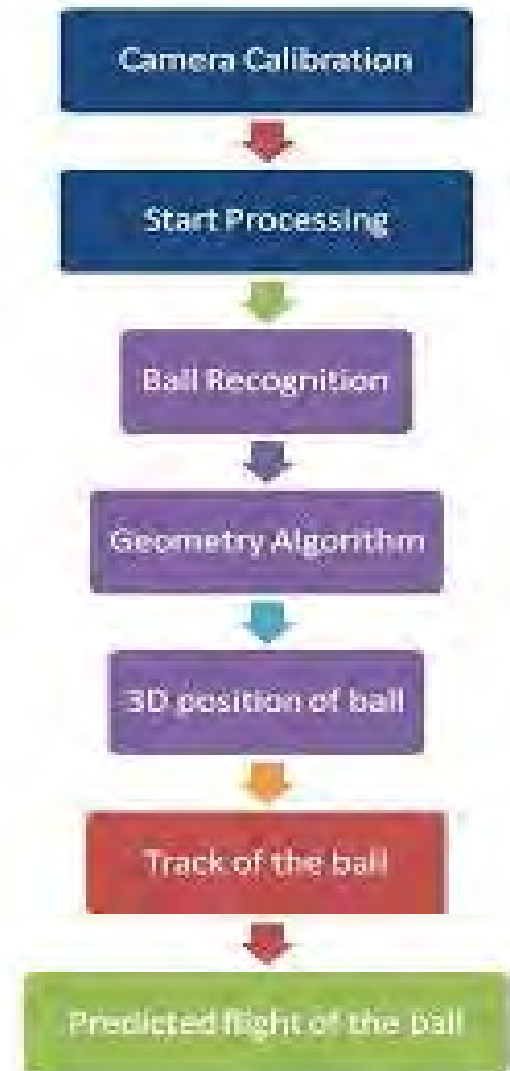
Speed Gun

- A speed gun measures the ball speed. It shoots a very short burst of infra-red laser and receives it back same as RADAR work.



Steps:-

- 1. The process is started with some calibration of the cameras. This is required to deal with the problem about the non-uniform distance of the cameras from the playing area.



Start Processing

- These might include a statistical generator, which is used to produce statistics based on the data collected.
- The statistics generator might also aid in storing data such as the average velocity of the ball.
- This data is crucial as it can help the ball detection algorithm to predict the rough location of the ball in an image given the position in the previous image

Color Image Processing Job

- An algorithm is used to find the pixels corresponding to the ball in the image obtained. The information which is used in order to achieve this is the size and shape of the ball not on its color.
- A blob detection scheme can be used to detect around object in the image.
- **blob detection** methods are aimed at detecting regions in a digital image that differ in properties, such as brightness or color, compared to surrounding regions.
- **Geometric Algorithm** is used to look at multiple images and then combine them cleverly to get the coordinates of ha ball in 3D.

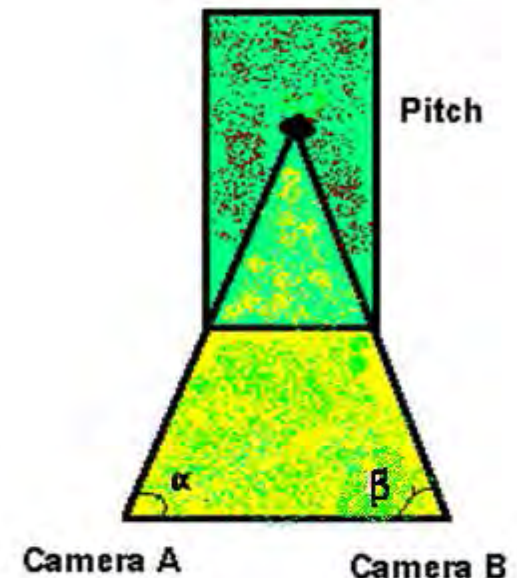
Principle of HAWKEYE

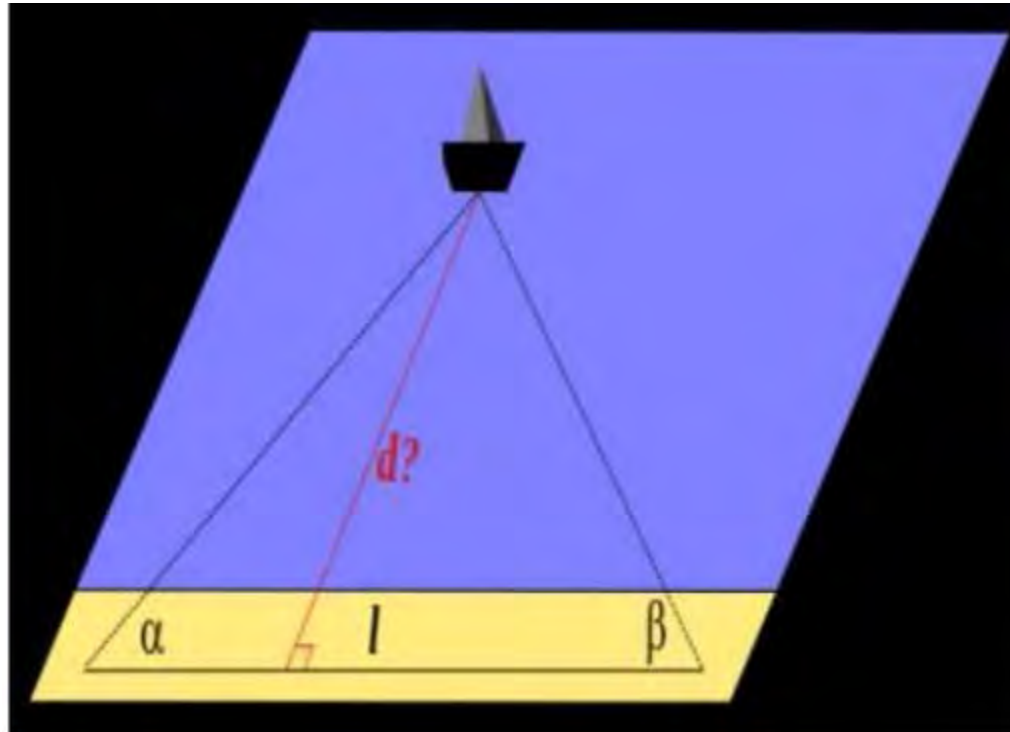
• Triangular Method:-

Triangulation is a process of determining the location of a point by measuring angles to it from either end fixed at baseline rather than measuring distances to the point directly.

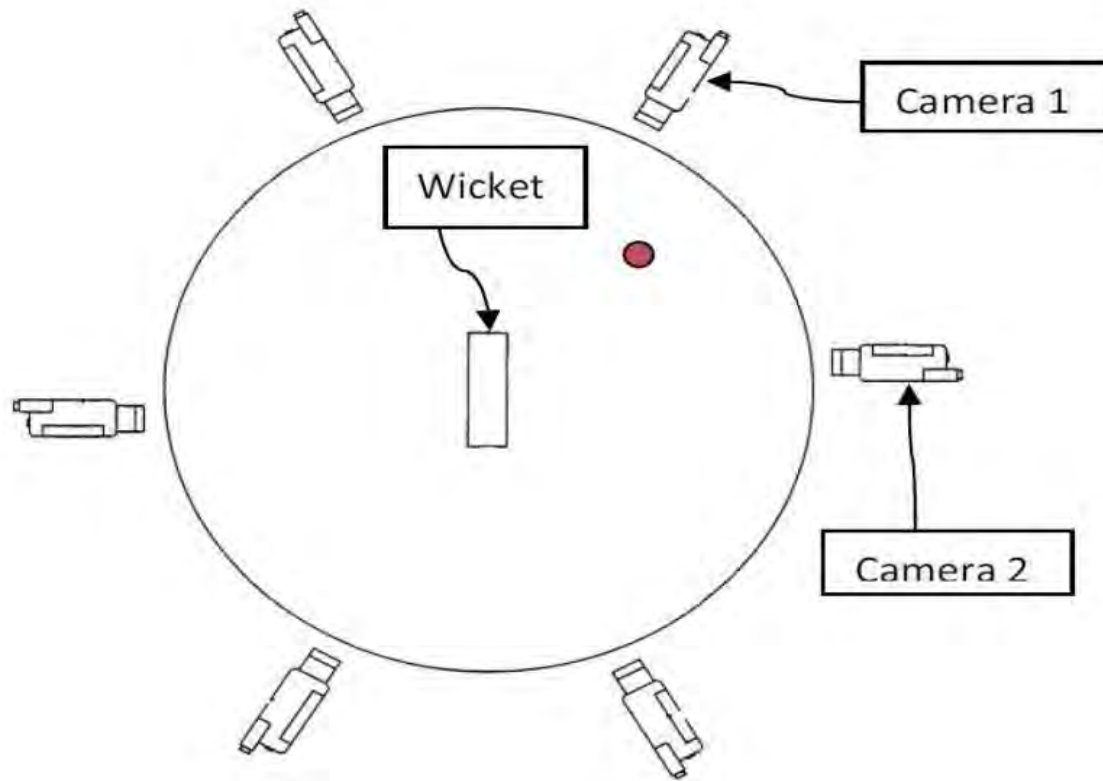
$$l = \frac{d}{\tan \alpha} + \frac{d}{\tan \beta}$$

$$d = l / \left(\frac{1}{\tan \alpha} + \frac{1}{\tan \beta} \right)$$





- By triangulation method we find the 2D coordinates of the ball.



- Depth of the ball can be calculated by the formula
$$\text{Depth} = r - (r \cos(\theta) + |x_1| * (\sin(\theta)))$$

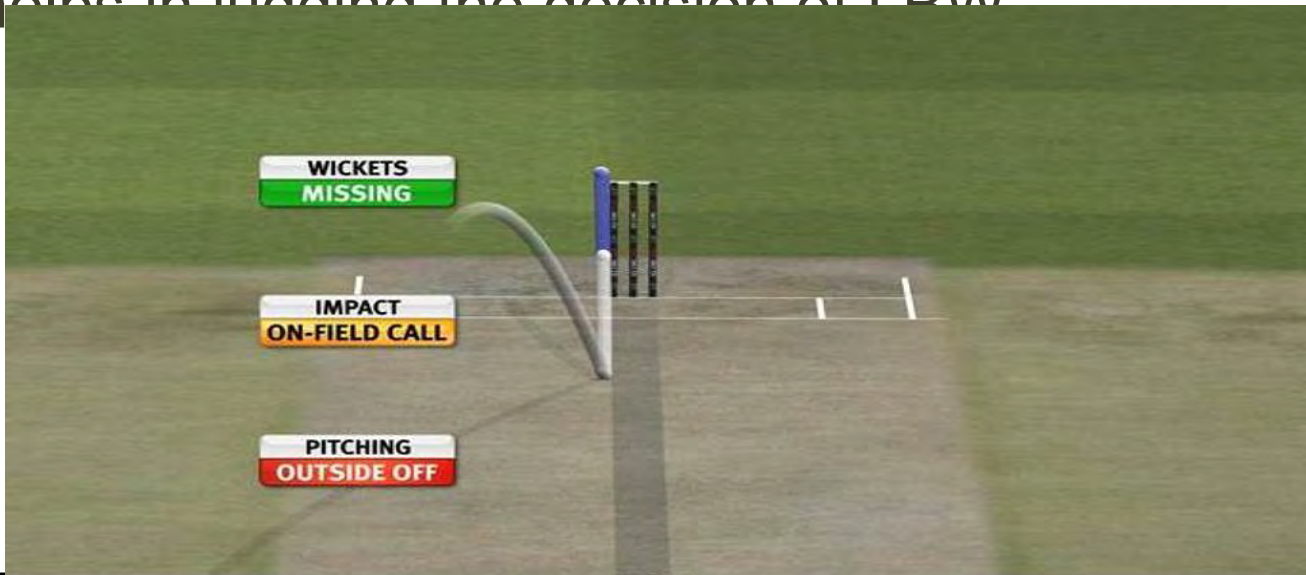
Tracking the ball at various instants

- The images are taken by cameras at times t_0, t_1, \dots, t_n during the play of a single ball.
- Computation done at each time instant t_i , $0 \leq i \leq n$, we will get n points say (x_i, y_i, z_i) for $0 \leq i \leq n$.
- Plot the n points.



Predicting the flight or trajectory of the ball

- There is a standard technique, used commonly in the field of **Computer Aided Geometric Design**.
- This allows us to draw as good an approximation as required to the original curve, passing through the given points.
- It helps in judging the decision of LBW

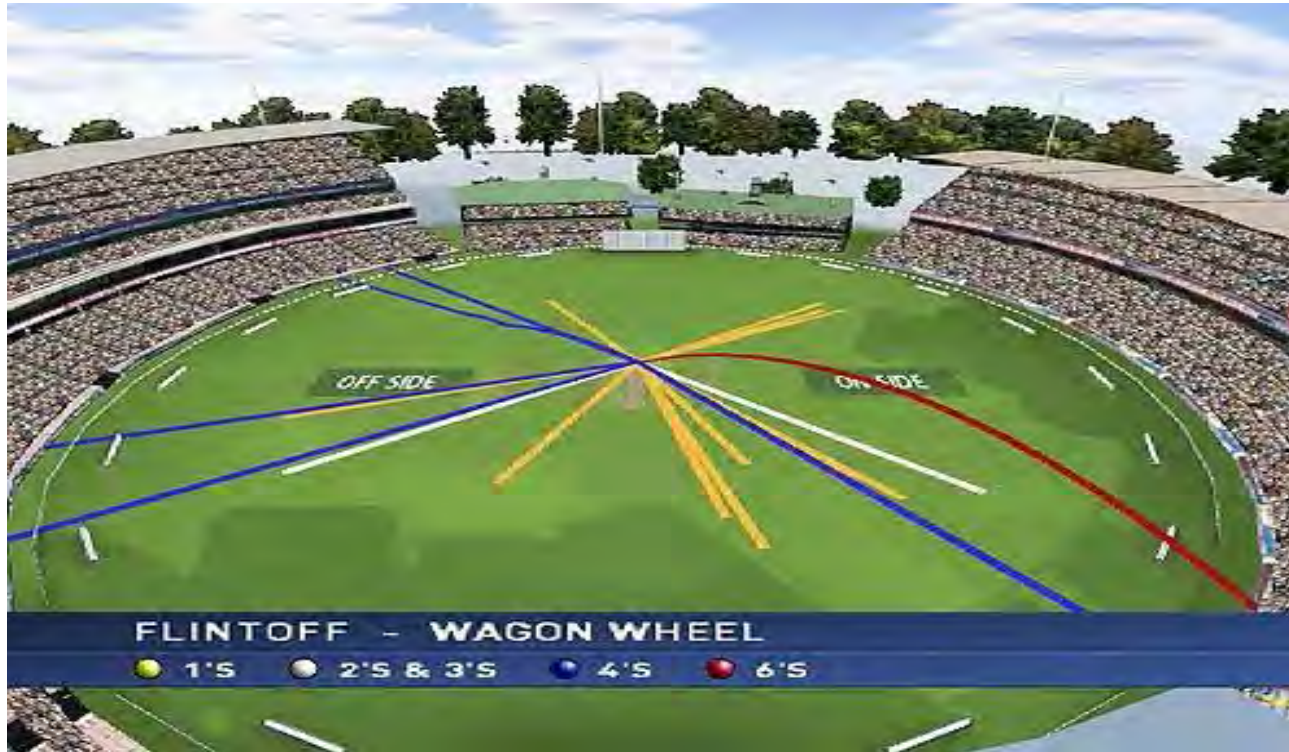


APPLICATION

- LBW



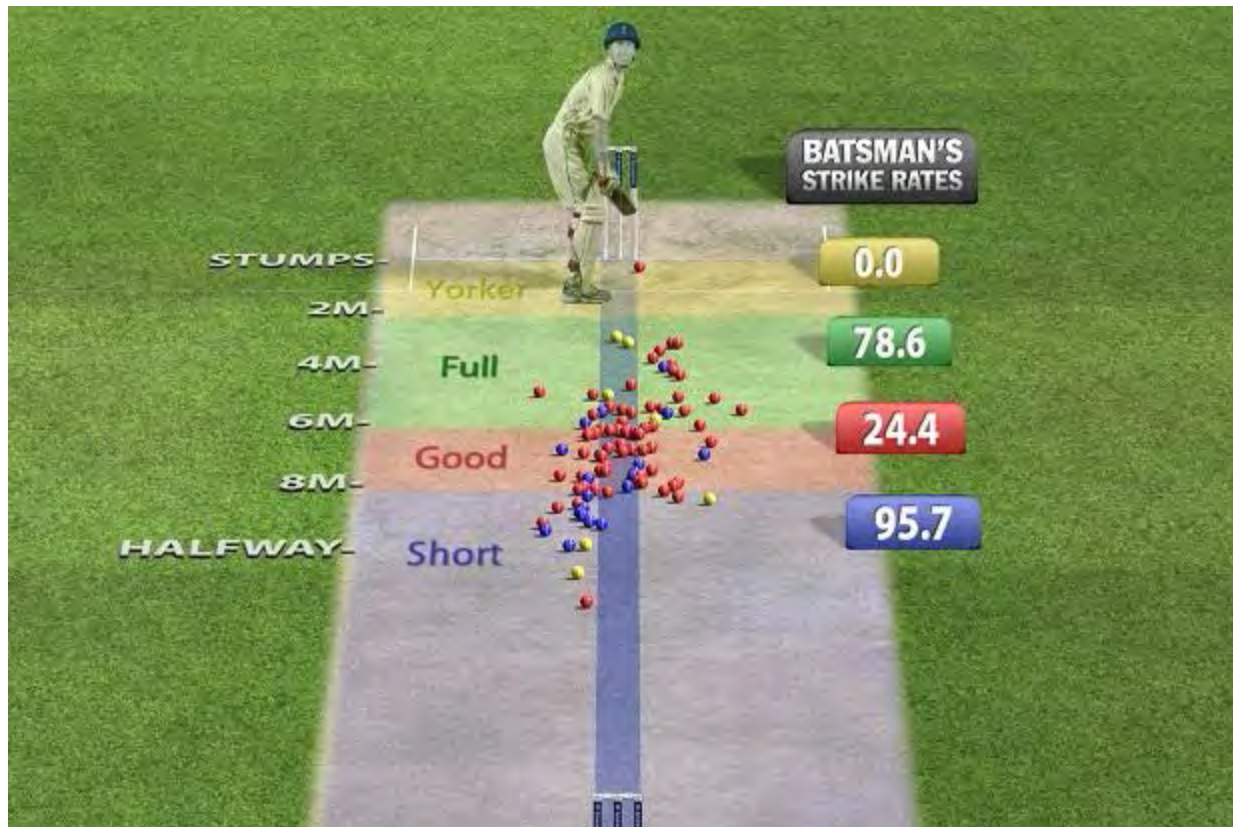
○ Wagon Wheels



The trajectories which the ball has taken after being hit by the batsman are recorded in the system. This is used to generate a graphic showing 1s, 2s, 3s, 4s, and 6s all in different colours for a batsman.

Pitch Maps

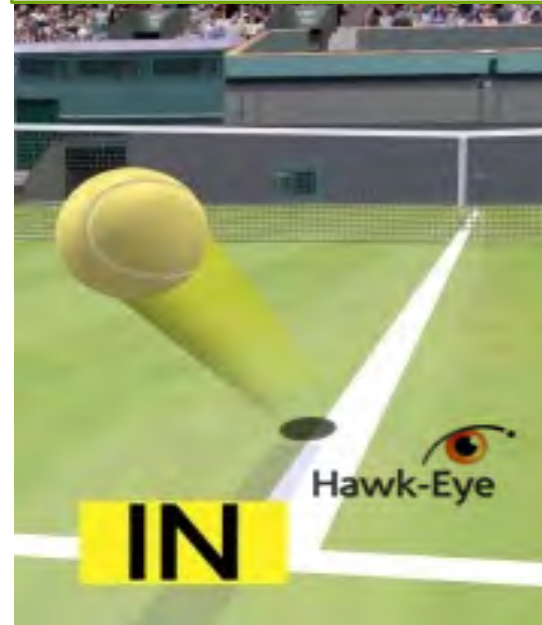
- As shown above, the Pitch Map graphic uses information about the position where the ball bounced on the pitch.



Other Sports

Tennis

- Hawk-eye was first used in tennis in the year 2004(US open tennis).
- In tennis Hawk-eye generates the impact of the ball whether the ball is “IN” or “OUT” the line of tennis court.
- There are appx. 8 to 10 high speed HAWKEYE camera at a speed of more than 2000 FPS/s for images, easy to capture the tennis trajectories and placement of the data.



FOOTBALL

- It is used in Football to judge whether it is goal or not.
- Hawk-Eye install 7 cameras per goal.

- Watch used by the Referee in Football also used Hawk eye Principal.
- Control software combines the information from all cameras and is able to track the ball within the goal area.
- As soon as the system detects that the ball has crossed the goal line, it instantaneously sends a signal to the official's watch.



In Automobile and Military Power

- The wheel alignment can be done by use of this technology in automobile industries.
- Track the enemy location from far away distance.
- The E-2C aircraft used by US army use this technology.



THANKS



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