



TECHNOLOGIES FOR MONITORING TRAJECTORY OF BALL

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Abstract: Recently, the increase in the number of sport lovers in games like football, cricket, hockey etc. has created a need for digging, analyzing and presenting more and more multidimensional information to them. Different classes of people require different kinds of information and this expands the space and scale of the required information. Tracking of ball movement is of utmost importance for extracting any information from the ball based sports video sequences. Detection is the first step of tracking. Dynamic and unpredictable nature of ball appearance, movement and continuously changing background make the detection and tracking processes challenging. Main intention is to evaluate the quickest way to detect the ball in any sport event in order to develop sports, AI without spending million dollars on tech or developers by comparing different technologies.

I. INTRODUCTION

Currently Technologies for monitoring the trajectory of a ball have come a long way in recent years. These technologies use advanced sensors, cameras, and software algorithms to accurately track the path of a ball in real-time. They are commonly used in sports such as baseball, soccer, tennis, and golf, to provide valuable insights into player performance and strategy. One of the most popular technologies used for monitoring ball trajectory is radar. Doppler radar systems can accurately measure the velocity and trajectory of a ball as it moves through the air, providing coaches and players with valuable information about the ball's speed, spin rate, and angle of release. Another technology used for monitoring ball trajectory is high-speed cameras. These cameras capture high-resolution images of the ball as it moves through the air, allowing analysts to track the ball's path and calculate its speed, spin rate, and trajectory. In addition, newer technologies such as 3D motion tracking systems and machine learning algorithms are being developed to provide even more detailed information about ball trajectory. These technologies are helping athletes and coaches to better understand the physics of ball flight, and to make more informed decisions about training, strategy, and game-day performance.

You do not need to watch too many games to know that referees have limited visibility and they too can make mistakes. Technology can change this by helping them make better and more accurate decisions. There are more technologies that can assist a referee on the ground (central referee) or through the third empire who is looking at the game from outside the ground (video assisted). These technologies are incredibly important because it is hard to keep an eye on all the players on the ground at one time while closely keeping watch on the ball. In order to give error free judgements, one should definitely use different technologies. Here mainly three main such technologies are being discussed, namely, Hawk Eye Technology, Goal Detection System and Snick-o-meter which are used in various sports and works based on different principle.

II. LITERATURE SURVEY

MLB Advanced Media LP, et al. describes in this paper as the ball tracking system is presented, detailing the major design considerations, and how the various technical challenges were overcome. This system is used in the sports broadcasting area.[1]

Chen, Q., and He, Y, et al. in this paper describes the implementation of Hawk Eye Technology. Hawk Eye Technology is a complex computer system used in cricket, tennis, and other sports to visually track the path of the ball and display a record of its most statistically likely path as a moving image. It is also used in some instances to predict the future path of a ball in cricket.[2]



Bartlett, R, et al. in this paper describes, where the stakes are increasing by every passing minute and an erroneous line-call can mean change of fortunes, there is an increasing reliance on technology to ensure that all arbitrations are unbiased. The component of human error in making judgments of crucial decisions often turns out to be decisive. It is not uncommon to see matches turning from being interesting to being one sided due to a couple of bad umpiring decisions.[3]

Oi, Y., and Moriya, T, et al. describes that there is thus a need to bring in technology to try and minimize the chances of human error in such decision making. Teams across the world are becoming more and more professional with the way they play the game. Teams now have official strategists and technical support staff which help players to study their past games and improve. Devising strategies against opponent teams or specific players is also very common in modern day sports. All this has become possible due to the advent of technology. Technological developments have been harnessed to collect various data very precisely and use it for various purposes.[4]

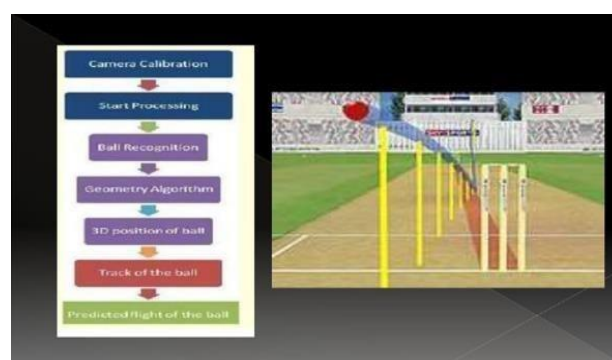
Blache, Y., and Morin, J., et al. in this paper describes that goal detection system is also one such technology which is really top notch in sports. The basic idea is to monitor the trajectory of the ball during the entire duration of play. This data is then processed to produce life like visualizations showing the paths which the ball took. Such data has been used for various purposes, popular uses including the LBW decision making software and colorful wagon wheels showing various statistics.[5]

III TECHNOLOGY INVOLVED

HAWK EYE TECHNOLOGY

It essentially involves processing, using cameras, not lasers. There are six calibrated cameras stationed at strategic points around the ground. As a ball is bowled each camera recognizes the ball in the image, a 3D trajectory of the ball is created from the image data using a process called Kalman Filtering. From this 3D trajectory, you can determine the speed, angle and deviation of the ball's flight. The Hawk-eye System is based on the principle of "Triangulation", which means the process of determining the location of a point by measuring angles to it from known points at either end of a baseline. This includes a computer and a camera system to trace a ball's trajectory in international cricket, tennis, soccer and many other sports.

It uses six or more computer linked TV cameras placed around the field, views from different TV's are then combined to produce an accurate 3D representation of the path of the ball. The technology then traces the ball's trajectory and sends it to a VR machine. High speed cameras are also used to take 600 frames a second on, for example, goal-line of the football. In each frame sent from each camera, the system identifies the group of pixels which corresponds to the image of the ball. It then calculates for each frame the position of the ball. And as shown below is Hawk eye technology.



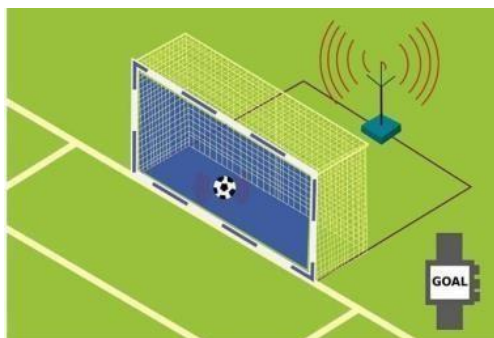
GOAL DETECTION SYSTEM

By providing low magnetic fields around the goals, Goal line technology creates the radio equivalent of a light curtain. As soon as the ball has wholly crossed the goalline between the posts, a change in the magnetic field is detected. A goal alert in the form of electronic waves is then instantaneously transmitted by the sensors to the game officials using an encrypted radio signals with a message displayed on the referee's wristwatches. The system uses a very small and compact electronic device embedded in the ball manufactured by select.

This is a radio-based system that uses low-frequency magnetic fields to determine whether or not the whole ball has passed over the goal line in a game of football. There are two magnetic field: one in the goal area, and the other created in and around the ball. Data is processed and then transmitted wirelessly to the referee's wrist watch. A message is



displayed in real time on the watch. Goal line technology is used to determine if a ball has crossed the goal line, to support the referee. In fig 4.2 shows a smart ball loaded with a sensor suspended inside can also be used, which network of receivers around the field designed to track the ball's precise position in real time. In football, goal-line sensors were introduced as part of goal-line assessment to give a definite decision on whether the ball had crossed the line.



SNICK O METER

Snick-o-meter has a very sensitive microphone that is located in the stumps. It records the sound from this stump microphone. This recording is cleaned up to remove the ambient sound i.e., sound from surroundings by filtering. This sound is then visualized in an oscilloscope-like thing or in a piece of music technology software which measures sound waves. If the ball hits nothing then the snick-o-meter graph shows a straight line and the graphs differ when the ball hits bat or pad. When the ball hits a bat, as bat is made up of wood produces a short sound when the ball hits it.

So a clean sharp spike is created in the snick-o-meter. While in case when the ball hits the pad, the impact is spread over a longer time and graph is obtained differently. It's basically used for cricket, this technology comprises a sensitive microphone embedded in one of the stumps and connected to an oscilloscope that displays sound waves. When the ball hits the bat, the oscilloscope trace picks up the sound.



IV ADVANTAGES

- The technology exposes the errors made by the umpires, hence saving time.
- Hawk-Eye is a handy tool for much more: its ability to track line, length, movement and speed means that it's a great aid in television coverage and for analysis.
- The whole process takes less than a second and is accurate to within 3.6mm that's just around an eighth of an inch.



V FUTURE SCOPE

Improved tracking accuracy: As tracking technologies continue to evolve, the accuracy of trajectory tracking will only become more precise. This is especially important for sports where the movements and speeds of the ball can be difficult to follow with the naked eye.

Integration with coaching software: The data collected from ball monitoring technology can be integrated with coaching software to help coaches and trainers provide more detailed feedback to athletes. This could help athletes improve their performance by pinpointing areas where they need to focus their training.

IV CONCLUSION

In conclusion, there are various technologies available for monitoring the trajectory of a ball, ranging from simple tracking cameras and radar systems to advanced computer vision algorithms and machine learning models. Each technology has its unique features, advantages, and limitations depending on the specific requirements of the application. Nevertheless, with the rapid advancements in technology, these systems are becoming more accurate, faster, and cost-effective than ever before, making them indispensable tools for coaches, trainers, analysts, and athletes alike. By harnessing the power of these technologies, we can gain a deeper understanding of the physics of ball motion, identify patterns in the performance of players, and develop data-driven strategies for improving team and individual performance.

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