



HAWK-EYE TECHNOLOGY

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ABSTRACT –

Cricket is continuously improving, and the progress can be attributed to advancements in sports technologies. One notable technological innovation in cricket is Hawk Eye, which has significantly enhanced the quality of the game. This technology has gained immense popularity among the public due to its extensive support. However, limited research has been conducted on Hawk Eye, leading to a perception influenced by legal aspects. Hence, the objective of this essay is to delve into the fundamental concept of Hawk Eye, its various applications in cricket, its precision and reliability, and propose recommendations for its future development.

Keywords -Hawk Eye, Technological, Perception

I.INTRODUCTION :

The Hawk-Eye technology has been extensively studied and reviewed by various researchers in the field of sports. In the 2020 Journal of Intelligent & Fuzzy Systems article titled "Hawk-Eye vision system for sports: A review," H. Wang, Y. Gao, and J. Zhang provide a comprehensive overview of the technology. They delve into the technical aspects of the Hawk-Eye system, including its camera configuration, image processing algorithms, and data analysis techniques. The article also discusses the limitations of the system and potential advancements that can be made. In 2011, J. C. Thomas and J. A. Elliott published "The Hawk-Eye system for sport: A review" in the Journal of Sports Sciences. This article offers a detailed description of the Hawk-Eye technology and its application in various sports. Cricket has experienced a significant rise in commercial importance and popularity in recent years. Consequently, there is a growing need to enhance the game's appeal to spectators and ensure fairness. The presence of human error in crucial decision-making often proves to be decisive, leading to matches becoming one-sided due to poor umpiring decisions. Therefore, the introduction of technology is necessary to minimize the likelihood of human error in such judgments.

Teams worldwide are adopting a more professional approach to the game. They now have dedicated strategists and technical support staff who assist players in analyzing their past performances and making improvements. Developing strategies against opposing teams or specific players has also become commonplace in modern-day cricket. All of this has been made possible by advancements in technology, which enable precise data collection and its utilization for various purposes.

The authors also critique the accuracy and dependability of the system. The television broadcasting industry has experienced significant growth worldwide, particularly in the realm of sports broadcasting. With a large audience at their disposal, broadcasting channels are engaged in intense competition to solidify their presence. By leveraging cutting-edge technologies, networks aim to enhance the viewing experience for their audience. One such technology, Hawk-eye, was developed by Dr. Paul Hawkins and engineers at Roke Monor Research Limited. Originally used by broadcasting networks, Hawk-eye has evolved into a crucial decision-making tool in various sports such as football, tennis, cricket, and snooker. In cricket, it aids in determining LBW (Leg Before Wicket) calls, serving as the sole ball tracking system available. The trajectory of the cricket ball is meticulously monitored throughout the game using data from multiple cameras. The concept of Hawk-eye and its applications are explored in the paper "Hawk-Eye: Augmented reality in sports broadcasting and officiating" by Paul McIlroy, published in IEEE Visual Information Engineering in September 2008. This topic falls under the Techathlon category, which focuses on the intersection of technology and athletics. Additionally, the article "Hawk-Eye technology: A comprehensive evaluation" by F. M. Hassan and S. Tariq in the 2018 International Journal of Computer Science and Network Security provides a detailed analysis of Hawk-Eye technology.



Figure1: Hawk Eye Technology

LITERATURE SURVEY

Hawk Eye Technology published by Madhu: Authors :P. Rathna Sekhar,N.R. Satish Kumar(2023). This article delves into the widespread use of technology in modern sports, highlighting its crucial role in enhancing the appeal of the games and expanding their popularity across the nation. Both direct and indirect participants in sports utilize technology in various ways. Specifically, this piece aims to shed light on a particular technology known as "HAWK-EYE," which has significantly contributed to making modern sports more captivating and error-free. "Hawk-Eye" is a widely recognized technology employed in sports such as Cricket, Tennis, and Golf. The term itself, "Hawk-Eye," originates from the concept of a bird's view, combining the words "Hawk" and "Eye." This technology greatly assists umpires and match referees in making accurate decisions. While there are other technologies like Ultra Motion and Hot-Spot that are also prevalent in modern sports, this article solely focuses on the "HAWK-EYE" technology.

Application of Hawk Eye technology to sports events published by Chenxi Liu, Wei Wang, Hairong Liu, Jun Wang(2023). This study delves into the rapid development of competitive sports in modern times, focusing on the Olympic motto "Higher, Stronger, Faster - Together". As competitions

become more intense, the speed of balls and athletes' movements also increases, potentially leading to referee errors that can negatively impact the game. Hawk-Eye, a computer vision system, plays a crucial role in addressing this issue. By visually tracking the ball's trajectory using high-speed cameras and analyzing it in 3D graphics through a Simultaneous Multi-Agent Recurrent system, Hawk-Eye ensures impartiality in the game, aligning with the Olympic spirit. The potential for expanding the application of Hawk-Eye technology in sports is vast.

A logical innovative technology use in sports for effective decision making published by Authors :P. Rathna Sekhar,N.R.(2022). Satish Kumar. This research paper delves into the utilization of Hawk Eye technology in sports for effective decision making. The study aims to shed light on the latest trends of this technology in the sporting world. Hawk Eye is widely employed in various sports and serves multiple purposes, including gathering interesting statistics, creating visually appealing representations of gameplay, and enhancing viewers' comprehension of umpiring decisions. Regarded as a cutting-edge technology, Hawk Eye meticulously tracks the ball's trajectory throughout the entire duration of play. This paper will explore how Hawk Eye effectively addresses these issues and offers a robust system for practical use. Originally developed as a replay system for TV broadcasts, Hawk Eye has proven to be a remarkable innovation that harnesses technology for the betterment of sports. The international impact of Hawk Eye is also examined by analyzing the data from its software, which ensures reliable decision making. Nowadays, this technology is extensively employed in sports like Tennis and Cricket.

TECHNOLOGIES USED IN ECG T-SHIRT HAWK EYE TECHNOLOGY

Hawk-Eye utilizes two key inputs:

1. Video footage captured by six distinct cameras strategically placed in exceptional positions.
2. The velocity of the ball.

The system efficiently processes video feeds through a high-speed video processor. Hawk-Eye combines photo analysis and radar technology. The digital camera operates at a frame rate of 120MHz. It tracks the complete path of the ball, from the moment it leaves the bowler's hand to the point where it reaches the batter. Hawk-eye technology is renowned for its application in various sports like tennis, cricket, football (soccer), and more. By utilizing multiple high-speed cameras strategically positioned around the field or court, it can monitor the trajectory and movement of objects, such as balls or players, in real-time. In tennis and cricket, Hawk-eye technology is predominantly used to track the ball's trajectory. Through a blend of high-speed cameras and computer algorithms, it can precisely determine whether a ball is in or out of bounds, or if a cricket ball would have hit the stumps. This technology has transformed officiating in these sports by delivering precise and immediate decisions.

CAMERA FUNCTION

The cameras used in Hawk-Eye technology play a crucial role in accurately tracking the trajectory of the ball in various sports. Here are some key aspects of the cameras used:

High-Speed Cameras: Hawk-Eye systems employ high-speed cameras capable of capturing footage at extremely high frame rates, often several hundred frames per second or even more. This high frame rate is essential for capturing fast-moving objects like balls in sports such as tennis, cricket, and soccer.

Multiple Camera Setup: Typically, Hawk-Eye installations consist of multiple cameras strategically positioned around the sports venue. These cameras cover different angles and perspectives to ensure comprehensive coverage of the playing area. By capturing the ball's movement from multiple viewpoints, the system can triangulate its position accurately.

Fixed and Mobile Cameras: Depending on the sport and the specific requirements of the venue, Hawk-Eye systems may use a combination of fixed cameras mounted in fixed positions around the stadium or arena, as well as mobile cameras mounted on movable rigs or towers. The flexibility to deploy both types of cameras allows for optimal coverage and adaptability to different venues and event setups.

High-Resolution Imaging: In addition to high frame rates, Hawk-Eye cameras also feature high-resolution imaging capabilities. This ensures that the captured footage is detailed and clear, enabling precise tracking and analysis of the ball's movement.

Infrared and Optical Sensors: Some Hawk-Eye systems incorporate infrared sensors or optical tracking technology to enhance tracking accuracy, especially in challenging lighting conditions or when the ball travels at high speeds. These additional sensors can supplement the camera data, providing redundancy and improving overall reliability.



Figure2: Hawk Eye camera

COMPUTER VISION

Computer vision forms the backbone of Hawk-Eye technology, enabling the accurate tracking and analysis of ball movement in various sports. Here's a deeper look at how computer vision is utilized:

Object Detection and Tracking: Hawk-Eye systems use computer vision algorithms to detect and track the ball in real-time. Object detection algorithms identify the ball within the video frames, while tracking algorithms continuously follow its movement across frames. These algorithms must account for factors like occlusions (when the ball is momentarily hidden from view) and changes in lighting conditions.

Feature Extraction: Computer vision algorithms extract relevant features from the video frames, such as the shape, color, and texture of the ball. These features are used to differentiate the ball from other objects in the scene and to accurately track its position and trajectory.

Motion Estimation: By analyzing the motion patterns of the ball across consecutive frames, computer vision algorithms estimate its speed, direction, and acceleration. This information is crucial for calculating the ball's trajectory and predicting its future path.

Depth Estimation: In some cases, computer vision techniques are employed to estimate the depth of the ball's position relative to the cameras. This information helps enhance the accuracy of tracking, especially in sports like tennis and soccer where the ball can travel at different heights.

Kalman Filtering and Smoothing: To improve the robustness of tracking and reduce the effects of noise and measurement errors, Hawk-Eye systems often incorporate Kalman filtering and smoothing techniques. These statistical methods predict the ball's position based on its previous motion and refine the tracking estimates over time.



Figure3: Computer vision in Hawk eye technology

DATA PROCESSING

Data processing in Hawk-Eye technology involves the analysis of tracked ball trajectory data to extract valuable insights about gameplay. Here is a detailed look at the data processing procedures.

Trajectory Reconstruction: Hawk-Eye systems capture the ball's trajectory data from various camera angles. Algorithms for data processing reconstruct the 3D trajectory of the ball by utilizing these multiple viewpoints. Through triangulation of the ball's position from different camera perspectives, the system forms a comprehensive trajectory path.

Speed and Velocity Calculation: By utilizing the reconstructed trajectory data, Hawk-Eye algorithms compute the speed and velocity of the ball at different points during its flight. This data aids in determining the ball's speed and how it changes over time, offering crucial insights into the game's dynamics.

Trajectory Prediction: Hawk-Eye systems often incorporate trajectory prediction algorithms that forecast the ball's future path based on its current trajectory and motion dynamics. These predictions can help players anticipate the ball's movement and make strategic decisions during gameplay.

Impact Analysis: In sports like cricket and tennis, where the ball can interact with various surfaces (e.g., bat, racquet, ground), Hawk-Eye technology analyzes the ball's impact to ascertain factors like ball bounce, spin, and deflection angle. This analysis assists in resolving close calls, such as line calls in tennis or LBW decisions in cricket.

Decision Support: Hawk-Eye technology offers decision support tools for referees, umpires, and coaches. Data processing algorithms present visualizations and analytics that aid in decision-making. Machine Learning and AI: Advanced machine learning and artificial intelligence algorithms are increasingly being integrated into Hawk-Eye systems to improve tracking accuracy and robustness. These algorithms can adapt to different playing conditions, learn from past data, and optimize tracking performance over time.



Figure4: Data processing in Hawk Eye Technology

APPLICATIONS

- Ball Tracking
- Impact point prediction
- Ball tracking in line with stumps
- Visualization for umpires
- Decision review system
- Umpire's Discretion

ADVANTAGES

- This technology is being used in many sports like Cricket and tennis.
- It is also a great tool which can be used by players satisfaction, tacticians, coaches to analyses previous games and come up with strategies for subsequent ones.
- It is used in automobile industries.
- It is used in military power.
- It produces the human errors It aids in game analysis and helps players perform better.
- It reduces the amount of effort required from humans, eliminates human error. Makes decision-making simple.

CONCLUSION

In summary, Hawk-Eye technology has brought about a significant advancement in sports officiating by offering precise and reliable ball tracking and analysis in sports like tennis, cricket, and soccer. By utilizing high-speed cameras, sophisticated computer vision algorithms, and advanced data processing techniques, Hawk-Eye systems provide valuable insights for players, coaches, officials, and spectators. The precision in tracking the ball's trajectory has transformed decision-making in sports, especially in crucial areas such as line calls, LBW decisions, and goal-line technology. This technology not only improves the fairness and integrity of the game but also enhances the viewing experience for fans through real-time analysis and interactive features. Looking forward, the potential of Hawk-Eye technology extends beyond sports officiating to include further advancements and applications. From increased accuracy and broader sports coverage to real-time analytics, fan engagement, and medical uses, Hawk-Eye technology is set to continue making a significant impact across various fields. As technology progresses and evolves, Hawk-Eye remains a pioneer, driving advancements and pushing the boundaries of sports analysis, performance tracking, and decision-making support. With ongoing research, collaboration, and innovation, Hawk-Eye technology will shape the future of sports and other domains, enhancing competitiveness, fairness, and enjoyment for athletes and fans globally.

FUTURE SCOPE

The future scope of Hawk-Eye technology holds promise for further advancements and applications in various domains beyond sports officiating. Here are some potential future directions. Enhanced Accuracy and Precision: Continued research and development efforts can focus

on improving the accuracy and precision of Hawk-Eye technology. This includes advancements in camera hardware, computer vision algorithms, and data processing techniques to track ball movement with even greater detail and reliability. Expanded Sports Coverage. While Hawk-Eye technology is already widely used in sports like tennis, cricket, and soccer, there is potential for its adoption in other sports and recreational activities. For example, it could be applied to track ball trajectories in sports such as basketball, volleyball, or golf, providing valuable insights for players, coaches, and officials. Real-Time Analytics and Insights: Future iterations of Hawk-Eye technology may incorporate advanced analytics and machine learning capabilities to provide real-time insights and predictions during sporting events. This could include player performance analysis, tactical recommendations, and game outcome predictions based on live data feeds.

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