Simulation of Decision Review system using Sound and Image Signals

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Abstract: **-** The Decision Review System (DRS) has completely changed the cricket umpiring by using the signal processing techniques which improves decision accuracy. This system uses high speed cameras and microphones, strategically positioned to gather essential visual and audio inputs by which it can record bat-ball interactions and track ball trajectories. Snickometer and Hot Spot technologies analyze synchronized sound waves and thermal images to accurately identify edges and ball contacts. By observing the ball's flight path, Hawk-Eye technology build up LBW rulings. Similarly, motion detection and object tracking techniques analyze the visual data frame by frame and it filters algorithms and also removes noise from auditory sources. This combination of technologies helps us to replicate the on- field events accurately, which provides a strong foundation for umpire rulings. Validation against the actual match situations ensures the system's strength and practical reality. The validation process makes sure the DRS simulation matches what actually happens in cricket matches by checking things like weather and pitch conditions. This helps make the system more accurate and trustworthy. This study shows how DRS connects theory from signal processing with real sports situations, turning technical ideas into practical tools used on the field. In the end, DRS is a great example of how science can make cricket fairer and clearer, giving players, umpires, and fans more confidence in the decisions made during the game.

Key Word*: Decision Review System, Snickometer, Hot spot technology, LBW decision, Hawk eye.*

I. INTRODUCTION

The Decision Review System (DRS) in cricket is a major step toward making umpiring decisions fairer and more accurate. To capture sounds and videos during the game it uses different tools like microphones placed near the stumps and highspeed cameras around the field. The Snickometer listens very carefully for any sharp sounds when the ball touches the bat and matches this sound with the slow- motion video and replays to confirm it . The Hot Spot uses special cameras that detect heat to show the correct spot where actually the ball hits. Hawk-Eye tracks the ball's flight to helps us to decide, if it would have hit the stumps or not, which is important for LBW calls.

The system cleans up the sound and video data to remove any background noise and keeps track of the ball's movement. All this information is altogether combined in a software which helps the umpires to review the tough decisions quickly and correctly. This combination of technology and smart computer programs shows how scientific ideas can be used in sports to make the game fairer and make sure that everyone trust the decisions made on the field.

II. LITERATURE REVIEW

In earlier days, decision-making in cricket relied solely on on-field umpires, whose judgement often became inconsistent in fast-paced or highly ambiguous situations. Traditional replay systems provided limited clarity since they depended only on 2D video footage, making it difficult to confirm faint edges or predict ball movement accurately. To overcome these limitations, researchers began introducing specialized technologies focusing on sound and image analysis.

A. Sharma et al. (2019) presented a fundamental audio detection model called Snickometer, which recognized abrupt

increases in sound amplitude to signal potential bat-ball contact, but faced challenges in noisy match settings. R. Patel and S. Kumar (2020) employed frame-by-frame image analysis to monitor the ball's path, obtaining enhanced precision but encountering challenges with quick movements and obstruction. Additional progress integrated visual and auditory signals for improved dependability. K. Verma et al. (2021) investigated infrared and thermal-based contact detection techniques; however, their high implementation costs limited their practical use in affordable systems.

A recent study by T. Banerjee and M. Iyer (2023) utilized inexpensive cameras and digital signal processing to mimic essential characteristics of DRS tools like Snickometer and Hawk-Eye, facilitating real-time event recognition with lower complexity. Studies collectively emphasize a transition from basic replay analysis to advanced, sensor-enhanced decision-making systems. This study expands on these advancements by modeling a cost-effective DRS system that utilizes synchronized audio analysis and image-processing techniques to identify edges and assess ball trajectory, providing enhanced decision support for cricket use.

III. MATERIALS AND METHODS

Gathering the required signals is the initial stage in simulating a Decision Review System (DRS) . A microphone that positioned close to the stumps in the ground records sound signals by capturing the sound of the ball while passing near the bat if the edge is there. To find edges for catches, this is crucial. High-speed like hawk eye cameras are positioned throughout the field to record image signals for make even more better. The system is able to follow the ball's trajectory because these cameras capture the ball's movement in several frames that will be monitored by a 3rd umpire. Digital storage of both audio and visual data provides unprocessed input for additional processing. Accurate signals are collected is ensured by placing cameras and microphones appropriately.

The signals are processed after acquisition in order to obtain useful information that taken from sounds and cameras. In order to determine if the ball has touched the bat, the sound signal is examined for spikes. Some Basic signal processing methods are used to filter out noise. The trajectory of the ball is tracked by analyzing the visual signal frame by frame using the cameras around the ground. The ball's route is ascertained by methods such as motion detection, frame differencing, and object tracking. The technology can forecast whether the ball will strike the stumps using this information. Accurate decision simulation requires both sound and picture processing. This stage connects the DRS simulation's raw signals with decision-making.

The final choice is then made using the signals that have been taken on field. An "OUT" is made if a spike is heard when the ball edged to the bat, indicating a potential edge the spikes are made. The choice is also "OUT" if the ball trajectory indicates that it would strike the stumps in an LBW situation when the ball is close to the stumps. The method shows "NOT OUT" if there is no spike and the ball miss the stumps or pitched around the pitch while the bowler bowls the ball from the around the pitch. This stage mimics the actual umpire's decision-making procedure. Accuracy and dependability are monitored by combining sound and picture data that will be monitored by the umpires. User can grasp the final result by viewing it as text or basic graphics. Programming languages that allow audio and picture processing, like Python, MATLAB, or Java, can be used to implement the DRS simulation in many monitors. Using sound signals and video frames as input, the application uses algorithms to monitor the motion of the ball while moving from the bowler's hand to batsman and identify edges if the ball touch the bat. Along with optional visual assistance like sound spike graphs or ball path charts these are used with hawk eye cameras, the system shows the decision. This enables users to view the analysis and comprehend the decision-making process. The application shows how signals and systems principles in sports technology can be used practically importantly in cricket, demonstrating how theoretical knowledge in day today life can be utilized in practical situations.

It is more crucial to verify the accuracy of the system we used after the simulation has been implemented in cricket. To make sure the choices reflect reality, simulation results are compared with real match conditions based on the weather conditions, bowling pitch or batting pitch, etc. For increased accuracy, thresholds for sound spike detection are taken and ball trajectory prediction can be changed in future. The system's performance can be assessed by

testing several scenarios, including edges, LBWs, hitting pad, hit wickets and missed balls. This validation process guarantees that the DRS simulation's dependability and illustrates on the practical application of signals and systems concepts. Appropriate validation shows the simulations useful for educational and sports technology applications and boosts confidence in its outcomes.

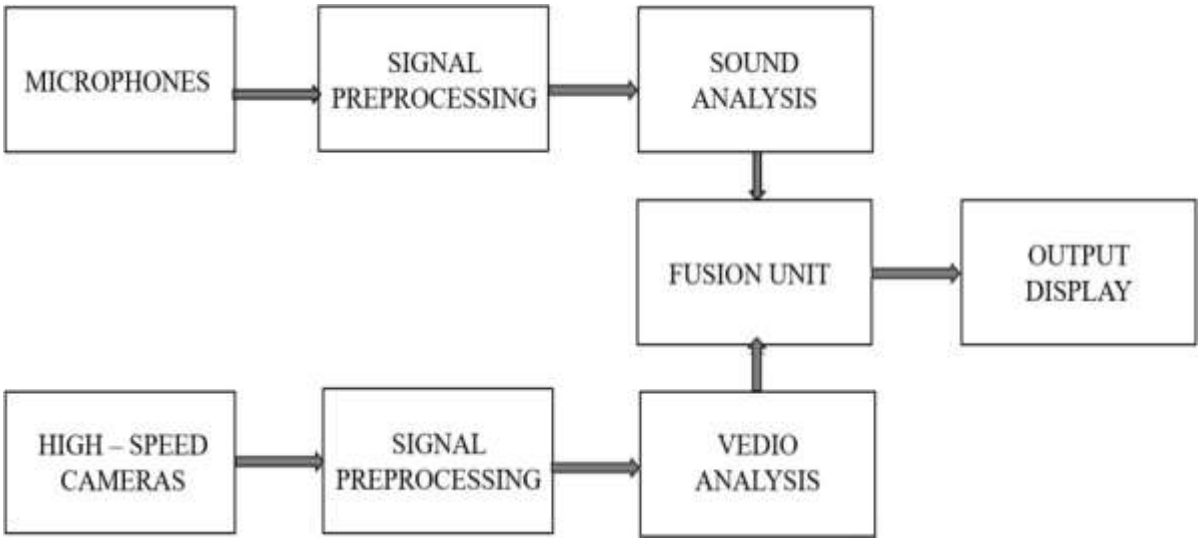

Fig 1: Block Diagram

The third umpire may use the Snickometer if players or on-field umpires use the Decision Review System (DRS). The technology helps determine whether the ball has come into touch with the bat, other equipment, or the player's body. The sound wave can be determined next to the frame by play motion. If there is a leather-on-willow sound, which is usually a short, abrupt sound that produces a sharp waveform, in time with the ball crossing the bat, the ball is deemed to have struck the bat. If it happens too soon or too late, it is determined that the spike on the waveform was not caused by the ball hitting the bat. If it happens too late or too early, it is determined that the spike on the waveform was not brought on by the ball hitting the bat. Other sounds, such the bat hitting the pitch or the ball hitting the batsman's pads, typically have a less distinct shape on the sound waveform, allowing for some degree of accuracy in identifying the type of contact that caused the sound. Microphones Sensitive microphones are placed near to the stumps and in the broadcaster's box to capture acoustic signals during gameplay.

The device analyzes the audio signals as the ball passes the bat to look for any odd sounds that would point to an edge. By receiving the audio signals from video, it converts into visual representation of the signal. Real-Time Analysis: During the crucial it offers clear and accurate decision. Snickometer often works in conjunction with Hotspot, an alternative tool that uses thermal photography to detect ball-to-bat contact and offers a comprehensive analysis of potential edges.

An oscilloscope is a type of electrical test device that graphically displays the fluctuating voltages of one or more signals as a function of time. It is sometimes referred to as an O-scope or scope informally. Recording electrical signal data for characterization, analysis, or debugging is their main purpose. The given waveform can then be analyzed for features like amplitude, frequency, rising time, time interval, distortion, and others. Initially, these values had to be calculated by manually measuring the waveform against the scales built into the instrument's screen. Modern digital gadgets can easily calculate and show these attributes.

An infrared imaging tool used in cricket, Hot Spot determines if the ball has struck the pad, bat, or batter. Hot Spot requires two infrared cameras that are placed on opposite sides of the ground above the playing area and continuously take pictures. Any suspected nick or bat/pad event can be verified by examining the infrared image, which frequently shows a bright spot where contact friction from the ball has raised the local temperature. When referrals to an off-field third umpire are permitted, the technology helps the on-field umpire make more accurate

choices. When referrals are forbidden, the method is primarily used as an analytical tool for television coverage. Hot Spot uses two infrared cameras at either end of the ground. These cameras identify and quantify the heat generated by friction when a ball hits a pad, a bat, the ground, or a glove. Using a subtraction method, a series of black-and-white negative frames are created on a computer to precisely locate the ball's point of impact.

III. RESULT AND DISCUSSION

The project Simulation of a basic Decision Review System using Sound and Image Signals, shows how mixing sound and visual data can make sports decisions more accurate and fairer. By this it will give a clear idea of how DRS works — by finding bat-ball contact using sound detection and detecting the ball's path through image processing. When both signals are combined, it helps reduce confusion if one of them fails, making the final result more trustable. The system works quite good in test conditions, but small problems like delay in synchronization and background noise still affect its accuracy. In future, better fusion methods and faster real-time processing can make the system more efficient and closer to real-world use. Finally, this simulation shows that multi signal processing can make automated decision systems smarter, faster, and more trustworthy in sports technology.

Fig 2: Ball tracking in DRS

Fig 2: This shows the ball tracking technology (like Hawk-Eye) which predicts the path of the ball after hitting the batsman, indicating if it would have hit the stumps (Wickets) or if the impact and Pitching points are valid for an LBW dismissal.

Fig 3: Ultra Edge and Impact analysis

Fig 3: This composite image demonstrates the use of Ultra Edge (a sophisticated version of Hot Spot / Snickometer) to detect contact between the bat and the ball (an edge). It also shows the full analysis display used by the third umpire, which include Original decision, wickets (Ball tracking prediction), Impact (Where the ball hit the pad / body), Pitching (Where the ball first bounced).

Fig 4: Snickometer showing possible edge

Fig 4: This picture shows a cricket moment using the Snickometer to see if the ball hit the bat. The sound wave on screen jump right when ball pass the bat, showing maybe small edge. It helps umpire to know if batsman is out or not in tight situation.

V. CONCLUSION

The Decision Review System (DRS) has really changed the way how today's cricket is being played. Smart tools like microphones to hear sounds near the stumps, super-fast cameras to see where the ball goes, and heat cameras to show where the ball hits are being used. This will help umpires to make better decisions and reduce the mistakes. The system removes background noise, checks both sound and video together, and can also guess where the ball will go next. It is tested often during real matches to make sure it works well in all kinds of weather and on different pitches. DRS shows how science and technology make cricket fairer and more accurate. It helps players, umpires, and fans feel confident that every decision is fair and proves how useful new technology is in today's game.

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