

Decision Review System in Cricket

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Abstract— The current Decision review system (DRS) protocol implemented by the International Cricket Council (ICC) allows a player to request a review of dismissal decisions taken by the on-field umpires. Reviews on various uncertainties may refer different technological components including hawk-eye/virtual-eye, hot-spot and snickometer/ultra-edge. The accuracy of the ball tracking system comes into play on practical usage, defining the overall error rate of the used technology along with the human error.

Index Terms— Ball, decision review system, error, hotspot, leg before wicket (LBW), review, technology, umpires.

1 INTRODUCTION

Under the decision review system (DRS) or the referral system, introduced and tested in an India v Sri Lanka match in 2008, and being officially launched by the ICC in 2009 during the first Test match between New Zealand and Pakistan at the University Oval in Dunedin, a player may request a review of the decision taken by the on-field umpire on whether or not a batsman is dismissed. The most common instances of referrals are for the leg before wicket (LBW) and caught behind. Most of the core rules and procedures adopted in cricket date back to the early years of its origin and are not tweaked unless a major appeal across the cricketing boards is issued, and one of them includes the decision of giving “out” (umpire raises his finger) or “not out” (by the shake of head) when there is an appeal from the bowler or the fielding team of a LBW or caught behind. Such decision is calculated and given by the on-field umpire at that brief moment only, generally it is expected to be fair and right but no method can eliminate human error and hence the introduction of DRS to aid such crucial decisions, but after many years of its use many have questioned its predictability of the ball tracking used in DRS. Upon gaining knowledge of the technology error with respect to human error and the amount of money invested in such technology one starts to look at the other way around.

2 PROCEDURE FOR DRS

For an appeal, adjudging a batsman/batswoman lbw involves a sequence of assessments: whether the ball struck bat before body; whether it pitched in line with the stumps; whether it would have hit, bypassed or bounced over the stumps; whether the batsman’s stride had taken him too far down the pitch for safe judgement; whether he used his pads with the express intent of obstructing the ball.

Depending on the result of the decision made by the on-field umpire, either the fielding captain or the batsman can ask to have the decision reviewed by a third umpire. The on-field umpire at the bowler’s end signals a square mime of a TV screen to prompt the third umpire to review the decision. The third umpire initially checks if it’s a legal delivery before proceeding to watch the replays to make an lbw or caught-behind decision. Ultra-edge (or snickometer) and Hotspot are the systems used to check whether the ball has made contact with the bat before hitting the pad (in the case of an lbw decision) or being caught by the wicketkeeper. If the ultra-edge doesn’t indicate a nick, the third umpire proceeds to review the impact before confirming with the ball-tracking software if the ball is indeed projected to go on to hit the stumps. Finally, there can be three possible outcomes of the decision taken by the third-umpire (i) “out” (ii) “not out”; and (iii) the evidence was “inconclusive”. If the on-field umpire had ruled the batsman out, he signals out after the third umpire conveys the decision. If the third umpire prompts his on-field counterpart to overturn his incorrect decision, he cancels his initial decision by touching each shoulder with the opposite hand before signaling out.

The third result namely the inconclusive one has been the talking point in the cricket community for a time now as the final decision rides on chance of agreement of the field umpire along with the DRS algorithms as the technology predicts the nature of the trajectory of the delivery and such factors are dealt in very small measurements (in millimeters). Various errors included may change the final result for the same delivery if replayed again. Such is the scenario of the inconclusive result or also called umpire’s call (on-field), which can be specified under such circumstances:

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1. Hawk-Eye predicts that only part of the ball would have struck the stumps as against either the center of the ball striking the stumps or the ball missing the stumps altogether.
2. Hawk-Eye predicts that only a part of the ball was inside the line of the stumps (as against either the center of the ball being inside the line of the stumps or the ball being entirely outside the line of the stumps) when it struck the batsman [2]. Therefore, for an LBW decision, if either the impact, the zone where the ball pitched or the projected ball path as it passes the stumps return as umpire's call, the on-field umpire's decision (out or not out) will be final. Teams, however, won't lose their reviews if umpire's call is involved in the final decision.

3 COMPONENTS

1. Hotspot: The Hotspot mechanism uses infrared imaging system to determine whether the ball has struck the batsmen, bat or pad. Every delivery in the match is recorded by the two cameras mainly located adjacent to each bowling end. Any suspected nick or bat/pad event can be verified by examining the recorded infrared image, which is done by identifying and calculating the amount of heat generated by the impact of the ball against another object. A negative image is then generated on a computer, on which the point of contact is highlighted as a red/white friction "hot spot". When the on-field umpire refers its usage, the same is used to enhance the final decision given to the respective team.

Although the technology can be used in various instances to assist the officials such as in checking the involvement of an edge or nick in an indecisive catch or for the analysis of the stroke play of a batsmen in middling the ball i.e. the sweet spot contact points. Although its primary application is in deciding whether the ball has struck the batsman's bat or pad- this determination being critical in ensuring if its out or not on an appeal for LBW. As we know in adjourning the batsmen out in the appeal for leg before wicket, the umpire has to make sure whether the ball struck the pad only, or the bat only, or (if it struck both) whether the pad or the bat was struck first. Thus infrared imaging can confirm such scenarios where the naked eye may not be able to distinguish it in the matter of a fraction of a second. The technology was first used during the first Test match of the 2006-07 Ashes at the Gabba, on 23 November 2006.



Fig. 1. Hotspot in Cricket. A spot is detected on the bat because of the temperature change detected by thermal imaging.

2. Hawk-Eye: Hawk Eye was developed in 2001 and put up for sale in September 2010, it was sold to Japanese electronics giant Sony in March 2011. The main goal is to have a continuous real time feed clicked from the six cameras strategically placed in the stadium each operating at the specific frame rate which is enough to capture the pitched delivery to provide data points for mapping the virtual trajectory of the ball. The third umpire refers to this technology when a referral for a LBW is sent upstairs to verify whether the ball was going on to hit the stumps if not interrupted by the batsmen leg. The umpire reaches to a conclusion based on three criteria namely: Where the ball pitched, i.e., in front of the stumps or not The location of impact with the leg of the batsmen after clearing out the possibility of any contact with bat or glove with Hotspot or Snickometer. The projected path of the ball past the batsmen

Often the last point is the deciding factor between an out and not out, with the software algorithms computing the predicted line of the delivery after considering length and swing of the delivery in question. Recently the procedure for referral was tweaked a little to include the checking of no-ball (bowlers leg stepping out of the crease) in case the field umpire missed calling for it. After the verification of a legal delivery, Hawk-Eye is rolled out. If any one of the points discussed above comes in favour of the batsmen he or she is adjourned not out if the review is taken by the batting side. Alternatively, there have to be three reds for a review to be in favour of the bowling side. In the case when the results are inconclusive in any of the steps, the final decision is given the same as the field umpire directed.

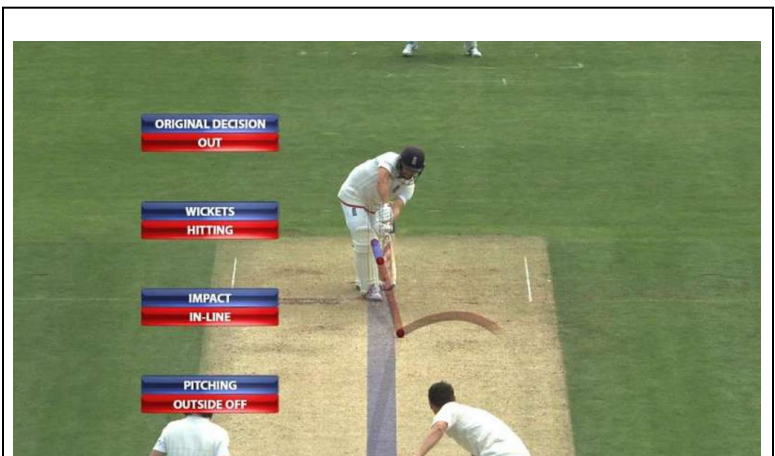


Fig. 2. Decision Review System in cricket. The third umpire checks the pitching spot and impact of the ball on the pads before checking the trajectory on the stumps.

3. Snickometer: It uses the stump microphone to pick up sounds in its surroundings, which helps the third umpire pick up the sound of ball hitting the bat. It filters out the noise and shows only the relevant signal like a waveform or a graph - a

sharp spike on the graph will conform the ball touch. The real-time snickometer automates the process of combining the visual and the audio in order to assist the final decision of conforming the edge of the bat. All the findings are live telecasted to the big screen and to the viewers at home to keep it transparent among the spectators. This component is cost efficient in terms of equipment requiring only stump mic and a camera but is prone to inconclusive decisions where sounds from other sources may creep in its results.

4 COST ANALYSIS IN DRS

More often than not we find a mainstream follower of the game generally not ruminating over the high expenditure of resources done for each game for an uninterrupted sequence of events in each review referred upstairs to the third umpire. The whole procedure is done in a matter of minutes but requires considerable amount of input ranging from the manpower able to operate a sophisticated technology for a full game of play along with the expensive equipment required to facilitate for the same.

The number of reviews taken in a particular format of the game is also an important factor in this, the limit of which being different for each format. The ICC put out a revised rule on the number of reviews allowed to each side at the start of every innings that is, maximum number of unsuccessful reviews for a team. In the Test format, each team can opt for two reviews in an innings in which if the decision to be referred upstairs is in sync with that of the on-field umpire than that review is lost and the final decision stays as the original one. On the other hand, if the decision is over turned by the third umpire then the team that had opted for the review does not lose their review count but the original signal is changed to the new one given by the third umpire i.e. usually given on the big screen along with the vocal conformation of the official. Now the last type of decision referred upstairs is the umpires call, which is the combination of both the procedures discussed above. The final signal to the player is given by the third umpire but stands the same as of the on-field's one without the team losing the review. Similarly, for ODI and T20 internationals the maximum review count is kept to one. Consequently, a side that has made all of its unsuccessful reviews cannot make any further reviews to the third umpire and must, accept the on-field umpires' decision as final.

Upon adding all the components needed for one review we can calculate the cost of using DRS per match which can be very expensive: on one estimate, the cost of DRS can range from US\$20,000 to US\$60,000 per match day with the use of Hotspot technology costing approximately US\$38,000. So, the per review cost of DRS will depend upon the number of reviews it called upon to adjudicate. By this model we can now compare how costly will it be for the hosting board to conduct a Test match which comprises of five match days. Also, depending on the number of successful reviews taken by the respective teams will make every match different to other from the financial perspective. Therefore, such a topic is bound to get into the headlines during the board meeting for the discussion of the scheduling of matches.

5 ACCURACY AND RELIABILITY

For adjourning the batsmen out or not out in an appeal for the LBW the umpire has to make such complicated decision in a matter of seconds and it is bound to include the human error factor in it hence the DRS can assist the team to opt for the intervention of third umpire in case they think the decision should be overturned. There is always a question of the accuracy with which the technology works as its decision cannot be referred again and is considered final. A cricket ball is not uniformly spherical. It has a raised seam around its equator and the two hemispheres become more asymmetrical as the game goes on. The trajectory of the ball after it hits the ground can vary enormously. The bounce can depend on the speed at which the ball is bowled which can be at times more than 90 mph (miles per hour), the hardness and texture of the ball also changes during the game, the spin on the ball and the position of the seam with the orientation of the ball. The "swing"- which is the aerodynamically induced curve in the flight of the ball may also depend on the parameters discussed above. As a result, the technology used in DRS to predict the post-bounce trajectory by examining the pre-bounce behaviour of the ball may include a variety of measurement errors. The basic principle of the algorithms used in it is to track and predict the path of the ball. Predictions are extrapolation and the accuracy of these extrapolations is limited by, among other things, the quality of data and no measurement is ever exact. In the case of uncertainty with the final decision upon reviewing may come majority in which include the dislodged bails (two sticks that sit atop the stumps) where the varying measurement error in every different review may prove to be the deciding factor on the final call. In practice, DRS digitization cannot correspond exactly with that of the bails in all cases because there are some circumstances in which it will not be able to predict with certainty whether the ball really would break the wicket including the small dimensions of the bails and the fact that the behaviour of the ball cannot be judged correctly each time it passes the wicket.

The final step after determining impact and the line of the delivery in a referral of the original decision is to check the breaking of the stumps and accuracy as discussed cannot be perfected and hence a certain error rate is defined as the principle of the imperfection in such measurements. The usual way of coping with measurement error in experimental science is to report a confidence interval of the errors. The width of the confidence interval is the function of two things: the confidence level which is chosen by the experimenter and the dispersion of the distribution of errors. If the dispersion of errors is known, then each prediction can be associated with a confidence interval defined by a chosen level of confidence such as 95 percent or 99 percent: the first would mean that it is estimated that there is only a 5 percent chance that the error is greater than the outer limits indicated by the 95 percent confidence interval; the second would mean that there is only 1 percent chance that the error is greater than the wider limits indicated by the 99 percent confidence interval. Such a standard deviation in each interval will be uniform if the database including pre-determined results of previously referred decisions is large enough to give us the pattern of reoccurring dis-

tribution. Another area in which the inconclusive decision in accuracy may be generated is the length between the point of impact on the pad where the batsmen is standing and the wicket (the longer the better). More number of data points (prediction of trajectory of the ball) will be available if the frame rate of the camera recording the delivery increases. It is commonly assumed the cameras operate at 120 frames per second and if the ball is travelling at 80 mph, it would travel one foot between frames without the accurate prediction of the course of delivery in that foot. Combining all the gaps in between the data points to chart the path of the ball after pitching of the pitch, we can say that there is lot of information regarding the conditions of the ball which cannot be determined using the ball tracking technology. Hence the accuracy of the technology used is limited to a certain range but along with the human intervention in the decision making this review system is bound to get investigated from a number of players and commentators.

6 CONCLUSION

Given the authority to declare a batsman out after virtually examining a compiled set of complicated procedural steps in an intense environment and to do it in a matter of seconds is easy to say that it is a challenging job. Due to many variables involved in this game certain technologies are being used in such modern times with a simple aim to make these type of crucial match winning decisions as accurate as possible. Upon the arrival of decision review system the response of cricket boards around the globe has been a sort of mixed reactions with some of them gracefully accepting it to strong disapproval towards it citing the reliability of technology used. Regardless, it is now an official decree from the ICC to include the concept of DRS in every international cricket match. The result of this is that international cricketers, in addition to the traditional skills of batting, bowling, and fielding, have to learn a fourth skill – the ability to use DRS effectively. A team could end up losing the game if the chances given to review a decision are not used properly. Another way that DRS has changed the nature of the game is that it has added considerably to the cost of staging an international cricket match. As we have argued, every day of international cricket requires a large amount of expenditure on DRS related infrastructure, which when compared with the percentage of successful reversed reviews is monumental. According to ICC's calculation the correct umpiring decision rate is around 90.3 percent and the rate after the decision is corrected by a review, i.e., post review is 95.8 percent. The gain from using DRS, in terms of an improvement in the percentage of correct decisions is minuscule relative to the large sums of money required for installing DRS, arguably, similar improvement in decision making can be harvested by investing in more training of umpires. Given the technical limits towards attaining higher accuracy and the increasing presence of this technology among the spectators, DRS has no choice but to advance.

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