

Out! Goal! The ball was in! But could Hawk-Eye get it wrong?

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Coming to a football stadium near you. Credit: Shuji Kajiyama/AP

Hawk-Eye is a device used to reconstruct the track of the ball for LBW decisions in cricket and for line calls in tennis. It will be much in evidence during the remaining Ashes tests and is now being used for goal-line decisions in Premier League football. The technology is at its best when officials make a really bad decision.

But there are things you might not know about Hawk-Eye. For instance, it cannot track the [ball](#) to a millimetre even though one might get this impression when watching some replays; in [tennis](#), those shots shown to be touching the line by a hair's breadth and called in might actually be out and vice-versa.

Few people realised that there was an issue with accuracy until my colleagues and I [wrote](#) about it in 2008; even top scientists were quite surprised until they thought about it.

How it works

Reconstructed track-devices such as Hawk-Eye work by using a number of TV cameras to record the position of the ball in each frame, then a computer reconstructs the path and projects it forward from the last frame.

These devices were first used to aid leg-before-wicket decisions in cricket. The projection-forward principle is the same in tennis since it is unlikely that a camera shutter will be open at the exact moment the ball hits the ground next to the line so the crucial position has to be estimated from a series of previous positions.

What we uncovered

From the frame-rate of the cameras and the speed of the ball, a back-of-an-envelope calculation gave the range of possible accuracy and it turned out to be less than the replays suggested. So we telephoned the firm to talk about it and we hit a wall. As sociologists of science we had spent decades chatting with scientists about this kind of thing but suddenly we were told this information was private and lawyers were on call. Before we could publish our first paper we had to ask Cardiff University to

back us in case we were hauled into court.

Our results were based on the range of possibilities for frame-rate and such other technical matters we could glean from the internet but detailed data for these devices was and still is secret. The International Tennis Federation refuses to release the details of its tests and the International Cricket Council also keeps its results under wraps. I have tried and tried to get the information from them and the scientists they commissioned to do the testing but am always met with the claim that the information is commercially sensitive.

Margins of error

The problem with reconstructed track devices is that their output is based on estimates. The position of the ball in any one frame is a blob of pixels. The future path of the ball must be extrapolated from at least three frames if the ball is swerving but if it is moving fast and the bounce point is near to the crucial impact point there may not be three frames.

Even with three frames, projections have errors and if, as in tennis, the ball distorts on impact, the footprint on which the line call is based is, again, the result of an inexact calculation – and so on. Hawk-Eye itself used to claim an average error of 3.6 millimetres; more recently it claims this has been improved to average of 2.2mms. However, particularly in tennis, the reliance on this technology to provide a definitive call means that this margin of error isn't reflected in the replays, leading most fans to assume it is 100% accurate.

Accuracy, of course, will depend on the speed and the angle of the ball and many other factors which is why these are average figures and, as with all averages, on occasion the error will be bigger – sometimes much bigger. To know what is going on one needs details of the tests and the

distribution of errors that resulted.

Tech and circuses

Assuming that tennis and football lovers, unlike enthusiasts for, say, the professional wrestling circus, want to see fairness as well as an entertaining spectacle, they ought to know more about how the technology is trying to work out what happened to the ball.

When the ball is really close to the line we should see something like a spinning coin to indicate that the final judgement has a lot of chance in it. The crowd would still get its decision and fun but something closer to the truth would be on display.

More and more, computers are able to simulate what looks like reality and this is dangerous for the future of society. The public needs to learn to question technological claims such as those that have been made for anti-missile weapons systems. In certain sports some spectators think that technology is infallible when it is not.

Paul Hawkins, the founder of the Hawk-Eye company, recently [said](#) our arguments were "typical of people who spent a lot of time in universities rather than on the tennis circuit". He's right, and thank goodness for that.

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