

# Hawkeye technology using tennis match

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## Abstract

In recent years, tennis has been widely spread and development of electronic information technology and popularization application in tennis. Hawkeye technology is through the trajectories of the high-speed cameras to capture the tennis, and through the digital imaging displays it on the electronic screen, thus provides the more impartial decision basis for the game. In view of this, this article through to the present situation and the application of hawkeye technology architecture, influence value are detailed analysis, trying to provide effective feasible Suggestions for it.

*Keywords:* tennis tournament; Hawkeye technology; structure analysis; applied research

## 1 Introduction

Tennis originated in the UK, and then spread to China, but as people living standard improving and the popularity of international competition, to promote tennis took to the wider development path. Tennis has jump as the second largest sports in the world, second only to football, thus people's love in the tennis. In the process of the development of tennis sport, some high-tech has been involved in, such as represented by "hawkeye" instant replay technology, this technology can be achieved by high-speed camera to capture the trajectories of the tennis and placement, often used in television, is now in the major events in the game has been widely applied. This article mainly analyzes the concept of hawkeye technology, and its application effect in tennis, in order to help us more comprehensive understanding of the features of this technology.

## 2 The basic concept of hawkeye technology

Hawkeye (Instant Replay) Instant playback system, is by the British Paul Hawkins (Paul Hawkin) of the invention, the technology is also the name of the surname from language Hawkins. Instant playback system is mainly composed of high-speed cameras, computers and electronic screens. First of all, with the aid of computer calculation to convert the three-dimensional space of the tennis court in mm measurement grid; Then, in the whole arena decorate 8~10 sets high-speed cameras, at a speed of more than 2000 FPS/s for images, easy to capture the tennis trajectories and placement of the data; Second, to transmit the data to the computer, through the system operation can generate tennis trajectories and placement of the 3 d image; Finally, through the real-time imaging technology, these images clearly displayed on the electronic screen, the entire data collection to late the imaging process of no more than 10 seconds, often used in the process of the television.

In 2006 the us open, hawkeye technology become the assistant referee decisions tools for the first time. In 2008,

the International Tennis Federation (International "Tennis" Federation, ITF), professional Tennis Federation, Association of "Tennis" Professionals, ATP), the International Women's professional made (Women 's "Tennis" Association, WTA) of all levels of the game and the Australian open, wimbledon and the French open Tennis tournament and the us open four grand slam events using the unified definition of hawkeye technology, in MeiYiPan game players have three hawk-eye challenge opportunity, if the game into a tiebreak, will accordingly increase the chance of a hawk-eye challenge. Image analysis hawkeye technology are shown in fig. 1 below:

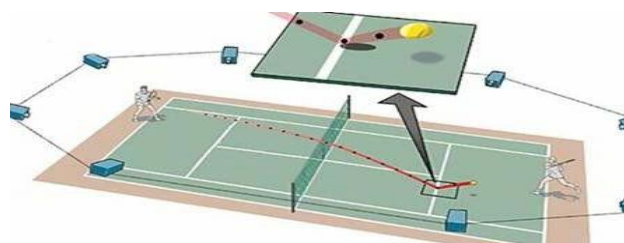


FIGURE1 hawkeye image analysis technology

## 3 Hawkeye technology application research in the tennis match

Before hawkeye technology is introduced in the tennis match, the referee to judge mainly consisted of tennis out line umpire calls for the standard, and as an important participant, the pitch of the players on the line umpire calls is no voice, but often the linesman miscalculation or false negatives will indirectly lead to the game. There is no denying the fact that the human visual judgment is limited, including the weather, Angle, obstructions, speed, distance, height, light and shadow, parallax, depth and color, the influence of such factors as these will directly affect the accuracy of the linesman to tennis out decisions. For example: serena Williams in 2004 U.S. open quarter-final against capriati, serena Williams with a very obvious win-

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ners are mistaken for out by the referee at that time through the use of instant replay system on TV shows in tennis obvious limits, and Jennifer capriati won the decider soon began to break opportunities in the Australian open final in the same year, played to a 6-2, Kim clijsters 3:4 backward, and be haining got a break point, Kim clijsters of a shot was sentenced to out at this time, however, from the television replay image analysis, the ball is hit no out online. Therefore, in order to further protect the rights and interests of the players themselves, improve the impartiality of the tennis match, hawk-eye technology promotion and application in the tennis match.

Hawk-eye challenge system can be divided into the referee just called a penalty, challenges time and adjust the number of three parts. In the tennis match, the referee is still the main body, hawk-eye technology play a supplementary role, and the timing of the hawk-eye challenge the refereeing decisions, times are mutually restricted, interdependent whole. When the referee did not see or Angle velocity faster more tricky situations can undertake hawk-eye challenge, the results of the determination results with hawk-eye challenge. Challenge opportunity is for tactical athletes and physical recovery is an effective way, number of challenges are important basis on the application of the hawk-eye technology normal game. Amounts of challenge, affect the continuity of the game and view and admire a gender. In 2009 Australia tennis open, Chinese athlete has three times in the MeiYiPan hawk-eye challenge opportunity, if enter the decider can add one more time. Hawk-eye challenge for players, if successful, the original challenge chance, if the challenge fails, will lose a chance to challenge. So for timing became the key player hawk-eye challenge, once the challenge fails, will not only lose a chance to challenge, but also will lose the points, to cause great psychological pressure.

According to the high-speed cameras frames per second 10000 photos can draw the following conclusion: tennis when in contact with the ground more than 3 milliseconds, and this one brief moment, the human eye is unable to see the tennis is the actual location. Therefore, only through the linesman personal experience and intuition judgment, combined with today's tennis player technology is more and more high, the ball speed and serve is becoming more and more fast, line umpire for site judgment is also more difficult. Hawk-eye for tennis referee report on a survey of the influence of cutting conditions are shown in Table 1 below:

TABLE 1 Hawk-eye technology investigation report on the effects on tennis referees of cutting

indicators	effect	N	Select the rate (%)
Hawk-eye on the influence of the cutting	A very large	0	0
	Have an impact on	7	70
	No effect	3	30

This article selects the NASDAQ - 100 open three events, the United States, the us open series and challenges to the hawk-eye of tennis players were investigated, the results as shown in Table 2.

TABLE 2 Tennis player hawk-eye challenge of success

Tennis tournament	Number of challenges	Number of successful	The success rate (%)
NASDAQ-100 open	161	53	33
The United States series	839	327	39
The us open	939	327	35
A total of	1939	707	36

According to results from our players to challenge the success rate is low, the referee's "vision" have the upper hand, which further verifies the hawk-eye technology to some objective factors affected by only miscalculation are correct. Due to the use of hawk-eye, not only provide a basis to judge fault, can also help us to get the player's speed, good service and the baseline data. The error control within 1%, from data acquisition to demonstrate show completed within 10 s. Hawk-eye technology using high-speed cameras in any position of velocity can be displayed, also can show changes of the tennis under the effect of air velocity. Has fulfilled the synchronicity of increased television time appeared in the process of handling of the ball, through hawk-eye technology to measurement of velocity, at any point in time to hit ball with velocity meter display, plus the hawk-eye tracking technology synchronicity, make its can direct feedback to the audience, the audience can players serve and skills to a more intuitive comparison and evaluation, but also enhance the look of a tennis match. Service is an important link in the tennis match, high-speed cameras can capture the athletes serve mode, and indicate the direction and depth, and the second hair so you can through the hawk-eye tracking can accurately grasp the characteristics of the player to serve, let the audience a view from another athlete's technology and tactics; The baseline data is using high-speed cameras to tennis movement trajectory tracking principle, produce many of the baseline data. Analysis of these data for athletes ability with a wide range of applications, coaches or commentators can on a technical analysis of the data, for example: player hit the ball bounce point, the response speed, the number of rounds, and the player's movement distance.

Through the above analysis, we can more clearly recognize the hawk-eye technology application in the tennis match, it is not to replace the referee, the main value is to overcome human observation ability of limit and blind area, help the referee out of accurate and fair judgment. The refore, we can see that the popularity of hawk-eye technology application is in order to improve the look of a tennis match, attract more fans to watch the tennis tournament, at the same time also provide the basis for improve the level of line umpire calls.

#### 4 Conclusion

Above all, headed by hawk-eye technology of high-tech has become a mainstream trend of modern athletic sports auxiliary decision, the most widely used of the tennis

match. With TV technology and the rapid development of Internet technology, the tennis match has not just the players on both sides of the technology, at the same time, the audience and the referee is also an important part of a wonderful game. In order to attract more people to watch the tennis match, increase the interactive and fun of the game, hawk-eye technology undoubtedly has a very important role. To this end, this paper deeply analyzes the hawk-eye technology used in tennis game, first understand hawk-eye technology principle, and combining with the international competition analysis of several important hawk-eye technology applied in the tennis match results, and the brief analysis of the hawk-eye technology in velocity determination, serves many functions such as contrast, the

baseline data, in order to explain the technology to the development of tennis sport has a great role in promoting. But due to the high prices and late hawk-eye technology maintenance, lead to the technology cannot be applied in most of the game of tennis, so, in the later research work should focus on hawk-eye technology upgrades and conduct the thorough research to the development of cost control, etc.

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