

Applying Strategies to the Tennis Challenge System

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Introduction

The new challenge system for close line calls in tennis has been used on the ATP and WTA tour for grand slam events since the 2007 Australian Open, and was designed to increase fairness for players by obtaining accurate line calls and enhance spectator interest through the use of video technology. In the current system, players have unlimited opportunity to challenge, but once three incorrect challenges are made in a set, they cannot challenge again until the next set. If the set goes to a tiebreaker game, players are given additional opportunities to challenge (usually one extra). If the match is tied at six games all in an advantage set, the counter is reset with both players again having a limit of up to three incorrect challenges in the next 12 games, and this resetting process is repeated after every 12 games. Having limited incorrect challenges raises questions as to when players should use their challenges to maximize the chance of winning. If a player was to use their challenges at every reasonable opportunity in a set, then they run the risk of running out of challenges on points that could significantly make a difference to the outcome of the set. If a player was too cautious in using their challenges early in a set, then he/she could lose the set with challenges left over and perhaps become annoyed with himself/herself for not challenging earlier when the opportunities were there.

Devising a model that accurately determines when players should be making challenge decisions is a complex process involving the rate at which challenges occur, the expected number of points remaining in the set, the number of challenges remaining in the set, the probability of the challenge decision being successful and the probability error that will occur if a wrong decision is made (known as the “importance” of the point). Further, the probability of the challenge decision being successful differs for each point that is played and is a subjective decision to be made by the player. Given all this objective and subjective information, it should come as no surprise that players have different views and strategies as to which points they will challenge on. This is reflected by an article *Replay System Becomes Part of Players’ Strategies* in The New York Times by Greg Bishop during the 2009 US Open.

<http://www.nytimes.com/2009/09/11/sports/tennis/11challenges.html>

Our task is to provide insight and strategies as to which points to challenge on to maximize a player’s chances of winning. Methods based on the work of Barnett and Clarke (2005), Morris (1977), Pollard and Pollard (2007a, 2007b) will be used to address this problem. This research could be used by players and coaches to possibly improve player performance.

Method

Importance of points

Morris (1977) defines the importance of a point for winning a game (I_{PM}) as the probability that the server wins the game given he wins the next point minus the probability that the server wins the game given he loses the next point. Table 1 gives the importance of points to winning the game when the server has a 0.60 probability of winning a point on serve, and shows that 30-40 and Ad-Out are the most important points in the game. In a similar way, we can define the importance of a game to winning a set and the importance of a set to winning a match. Table 2 gives the importance of games to winning a tiebreaker set (I_{GS}). Player A and Player B were assigned point probabilities of 0.62 and 0.60 respectively to reflect overall averages in men's tennis. It is clear that every point is equally important for both players. Table 2 shows that the tiebreak game has the highest importance of 1.00, as the winner of this game wins the set. Morris (1977) derived the following useful multiplicative result: For any point of any game of any set, $I_{PM} = I_{PG} * I_{GS} * I_{SM}$. Based on this result it is clear that the importance of any point to winning a set (I_{PS}) is given by $I_{PS} = I_{PG} * I_{GS}$.

		Receiver's score				
		0	15	30	40	Ad
Server's score	0	0.27	0.35	0.37	0.25	
	15	0.21	0.33	0.44	0.42	
	30	0.13	0.26	0.46	0.69	
	40	0.05	0.12	0.31	0.46	0.69
	Ad				0.31	
	Ad					

Table 1: Importance of points to winning a game when the server has a 0.60 probability of winning a point on serve

		Player B's score						
		0	1	2	3	4	5	6
Player A's score	0	0.27	0.29	0.29	0.18	0.13	0.02	
	1	0.26	0.30	0.33	0.32	0.16	0.09	
	2	0.16	0.29	0.34	0.37	0.36	0.11	
	3	0.13	0.16	0.33	0.39	0.43	0.42	
	4	0.03	0.11	0.14	0.38	0.48	0.54	
	5	0.01	0.02	0.08	0.10	0.46	0.48	0.53
	6						0.47	1.00
	6							

Table 2: Importance of games to winning a tiebreak set when player A has a probability of 0.62 of winning a point on service, and player B has a probability of 0.6 of winning a point on service

The definition of importance of a point in a set is a way of stating how much difference will result in the outcome of the set depending on whether a point is won or lost. In the context of a challenge system,

importance of a point in a set can be viewed by how much percentage error will occur if a wrong decision is made. For example, suppose the score in a best-of-5 set match (all tiebreak sets) is 2-2 in sets, 5-5 in games and 30-30 in points and player A is currently serving. Suppose player A is winning 62% on serve and player B is winning 60% on serve. Using a Markov Chain model (Barnett and Clarke, 2005), player A has a 51.5% chance of winning the set (and match) from that position. If player A won the point, then his chance of winning the set and match would be 60.3%: whereas if player A lost the point then his chance of winning the set would be 37.3%. Therefore the importance of the point is given as $60.3\% - 37.3\% = 23\%$. If a wrong decision was made at that particular point in the set, then it would cost one of the players 23 percentage points in their chance of winning the set. Based on this reasoning, players should base their decisions on challenging calls depending on the importance of the point. As an aside, it is worth noting that 30-30 and deuce are equally important, as are 40-30 and Ad-In, and 30-40 and Ad-Out.

Expected Number of Points Remaining in the Set

Consider the two possible score lines of a) a player serving at a game score of 2-2 and b) a player serving out the set at a game score of 5-2. Further, suppose the player had one challenge remaining for the set. At 2-2, the player may choose not to challenge at this stage in the set, realizing there are many more points left to be played, and could possibly save this challenge for a point of greater importance. However, at 5-2, the player may choose to challenge at this stage of the set, realizing that winning the set is only a few points away, and therefore seeking out every bit of advantage. A player should not be discouraged about making incorrect challenge decisions and should be encouraged to challenge line calls as a gamble when close to the end of a set. What this indicates is that a player's decision on when to challenge could be based on the expected number of points remaining in the set.

Probability of success from challenges

A player's decision on whether to challenge a particular point could be based on their probability of success. These probabilities are subjectively based from the player's perspective. A player is likely to have more confidence on a line call that is directly in front of them, as opposed to a ball that is on the opponent's base line. It would seem reasonable that linesman errors are dependent on the speed of the shot and this information should be taken into account when deciding on whether to challenge on a particular point. A player should be "fairly" certain on challenging a line call during a rally, as they run the risk of losing the point if the challenge is incorrect. Table 3 represents the challenge summary for the men's and women's singles matches played at the 2009 Wimbledon. Men's matches are best-of-5 sets whereas women's matches are a best-of-3 set, which explains why the total number of challenges is significantly higher for men. On average there are approximately 4.1 sets played in a men's match and 2.5 sets played in a women's match. From the average challenges per match given in table 3, this amounts to $6.68/4.1 = 1.6$ challenges per set for men and $3.82/2.5 = 1.5$ challenges per set for women. On average players are successful on challenged calls about 30% of the time (given in table 3), based on approximately 0.8 challenges per player per set.

	Men's Singles	Women's Singles
Total Number of Challenges	314	130
Number of Correct Challenges	93	38
Number of Incorrect Challenges	221	92
Percentage Overturned	29.62%	29.23%
Avg. Challenges per Match	6.68	3.82

Table 3: The challenge summary for the men's and women's singles matches played at the 2009 Wimbledon Championships.

Rate of occurrence of challenges

A player's decision on whether to challenge a particular point could be based on how often challenge opportunities are likely to occur. A player who tends to hit close to the lines on either serving or ground strokes could possibly be presented with more challenge opportunities than a player that conservatively tries to always get the ball back in the court and minimize errors. The speed of the shot could influence how often challenge opportunities occur, as it would be expected that linesman would make more errors on shots with a greater speed. It is clear that player's should be more willing to challenge line calls as their rate of occurrence of challenge opportunities decreases. From above, players are currently making 0.8 challenges per set which is resulting in a 30% success rate.

Results and Discussion

Various methods were described in the above section that provide insight as to which particular points players should challenge on based on the rate at which challenges occur, the expected number of points remaining in the set, the number of challenges remaining in the set, the probability of the challenge decision being successful and the importance of the point to winning the set.

At the 2009 Wimbledon Championships, IBM was experimenting with a new way to experience a tennis match on-line, known as "Visual Match". The feature allows the fans to identify and explore the momentum of a tennis match in a graphical format. Similar graphic displays could be used during a match in progress to include estimated probabilities of winning, importances of each point and the expected number of points remaining. This information could be useful for players and coaches in making challenge decisions.

A mathematical model could be developed that could assist players as to which points to challenge on so as to maximize their chances of winning. This analytical method using dynamic programming (Pollard and Pollard, 2007a and 2007b) turns out to be very complicated for a full set of tennis. However, our study of some simpler but related scoring systems has given us some insights into the player's dilemma as to whether to challenge or not. For example, if a player is playing a first-to- n points match, *and all his possible challenges (wherever they might occur at random) have the same probability of success*, then no matter what the score is, and no matter how many challenges a player has left (even if it is only one

and n is large), he should challenge until he runs out of challenges (even if the point to be challenged has a small importance). We found this to be a very interesting result, and it does indicate that it can make sense to challenge even when it may appear intuitively reasonable not to challenge. Also, it is clear that, in the above example, if there are two levels of challenge success rather than just the one level, it can be optimal to forgo a challenge at the lower success level in order to save this challenge for possible use at the first higher success level. Our considerations of such simpler but related scoring systems has led to the interim recommendations below.

Some recommendations based on dynamic programming analyzes of relevant, simpler and related scoring systems are:

1. The additional challenge given to the players if the games score reaches 6-6 in the set would appear to be sufficient in most cases for the tiebreak game about to be played. Thus, there would appear to be no real problem with a player using all 3 challenges by the time the score reaches 6-6. However, it would appear to the authors that it would be a reasonable proposal to give the players an additional challenge each if the point score within the tiebreak game reached 6-6, as the points are very important at that stage, and a wrong call can 'destroy' the match outcome.
2. It would appear a sensible strategy for players overall to increase their rate of challenging from the current average value of about 0.8 challenges per player per set, even though it would presumably decrease the average success rate (currently at 30%) per challenge for the players.
3. With 3 challenges remaining it would appear to make good sense to challenge even quite early in the set if the relevant point was moderately 'important'. With 3 challenges remaining and only a few games left to 6 all, players should not be too worried at all about running out of challenges before 6-6, and so should challenge wherever they feel they want to with some degree of success.
4. With only 1 challenge remaining and say about 4 or more games to go to 6-6, players should challenge on only quite important points provided they feel they have a reasonable chance of success.

The following recommendations are based on observational and quantitative results:

1. When a player is serving for the set, players should be encouraged to challenge on close line calls, particularly on faults and service winners.
2. Since linesman errors are dependent on the speed of the shot, players should be encouraged to challenge close line calls on faults and service winners.
3. Players should usually challenge on a close line call in a tiebreaker game – even with only 1 challenge remaining.
4. Players should consider challenging an over-rule from the chair umpire, particularly if the linesman had a clear view when making the line call.

5. Players should be “fairly” certain on challenging a line call during a rally, as they run the risk of losing the point if the challenge is incorrect.

6. A player is likely to have more confidence on a line call that is directly in front of them, as opposed to a ball that is on the opponent’s base line.

7. Coaches signaling challenge decisions to players are within the rules of tennis, and this resource should be utilized by players and coaches. Mobile computer technology could possibly be used in making these decisions during the match in progress.

Conclusions

This article has given an insight and provided strategies as to which points to challenge on to maximize a player’s chances of winning. This research could be used by players and coaches to possibly improve player performance.

References

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