Analysis of Winning Factors in Tennis Match based on Fuzzy Judgment

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Abstract

The incredible victories that happen to players of varying strength seem to be the success factor often attributed to "momentum". In sports, a team or an athlete may have "momentum", "Zhouyi" is the oldest prediction, it can be said that China is the originator of scientific explanation "momentum".In a game/match, while winning or losing is difficult to measure, "momentum" can change, and obviously, how to create your own winning momentum in a game is the focus of this article. First of all, data preprocessing was carried out, Using the distance and Angle provided by the Wimbledon tournament website,the speed calculation formula was created by itself to calculate the missing service speed data , and the calculation formula of fortune was put forward as (the number of times to end a point)/(the chance to end a point), and it was verified that the accuracy of predicting the win or loss of the match by fortune was 58%.   In the 2023 wimbledon-1701 game, Carlos Alcaraz scored 0.174639307 and Novak Djokovic scored 0.138898286. So Carlos Alcaraz beats Novak Djokovic.We can explain the existence of "momentum" by using the prediction of winning and losing results of 31 games.By using fuzzy judgment to predict the fortunes of players with large difference in strength, the correct rate is higher.

Keywords

Standardization; Feature Engineering; Fuzzy-judgment.

1. Introduction

In the 2023 Wimbledon men's singles final, 20-year-old Spanish rising star Carlos Alcaraz defeated 36-year-old Novak Djokovic. Alcaraz appeared to be in complete control at the start of the fourth game of this match, but somehow the match changed direction again and Djokovic took complete control, winning the sixth set, but then again the direction changed and Alcaraz took control, winning 6-4. These in the data set provided, "2023-wimbledon-1701" can see the whole process, the incredible swing of the player, as if the player suddenly has some kind of advantage, namely "momentum," which is the intensity or force gained through movement or a series of actions. [1].

In sports, a team or athlete may feel that they have momentum, or "momentum." This phenomenon is difficult to measure in a game/match. In addition, it is not easy to see how various events in the tournament create or change momentum by providing data on every point of the 2023 Wimbledon men's singles tournament to help discover "momentum".

2. Analysis of Winning Factors in Tennis Match

2.1 Preparatory Work

Combined with the background and problems, our work mainly includes the following aspects:

•We assume that the outcome of all matches (except those between fairly close players) is predictable. The real existence of fortune is verified by establishing fortune calculation formula.

•We will have three levels of indicator atmosphere affecting fortune, use multi-level fuzzy evaluation to detect the fortune of the contestants in real time, and verify whether the DEA is effective with DEA.

2.1.1 Model Assumptions

In order to simplify the real problem and abstract the mathematical model, we make the following assumptions:

Hypothesis 1: The player's serve is at the point of the nine-nine grid,

Hypothesis 2: The mentality of the players is adjusted quickly, and the mentality during the competition only affects the performance of a certain period of time (no more than 1 minute).

2.2 Data Preprocessing

Carefully study the competition data provided to understand the data structure, characteristics and labels. Perform data cleaning: deal with missing values, outliers, and ensure consistent data format.

Then the data is merged and processed, and the pre-processed data is obtained by missing value processing, removing outliers, normalizing and standardizing a series of operations.

2.2.1 Handling missing values

One missing place: there is NA in the serving speed in the attachment, but the player is missing one place, such as 752 missing places, and only one data is missing in the hitting speed of the player. The data can be filled with Langrange interpolation to ensure the integrity of the data.

To find this curve over n points is to find a polynomial of degree n-1:

$$y = a_0 + a_1 x + a_2 x^2 + \cdots + a_n x^{n-1}$$

Bring n points $(x_1, y_1), (x_2, y_2), \ldots, (x_n, y_n)$ into the above polynomial and solve it simultaneously to obtain the Lagrange interpolation polynomial:

$$L(x) = \sum_{i=0}^{n} y_i \prod_{j=0, j \neq i}^{n} \frac{x - x_j}{x_i - x_j}$$

Multiple omissions: All missing batting speeds of the players in the attachment must be calculated by adding the calculation formula, such as all missing batting speeds of the two players in the attachment.

Calculate according to the following formula.

①Determine the landing point

The landing point is the size of the tennis court as shown in the figure below. Since the speed direction of the ball when serving is mainly in the horizontal direction, in order to facilitate calculation, we only consider the distance passed by the ball in the horizontal direction.

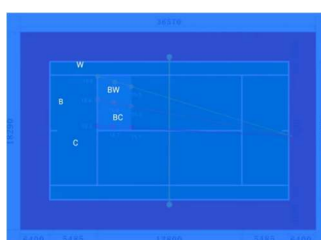②Calculate the length of various lines in the service area as shown below:

Figure 1. Schematic diagram of the tennis ball landing position

The landing zone of the simple serve is nine points, so that the length of each line is the distance of the ball, respectively:

18.8, 17.1, 15.5

18.4, 16.8, 15.2

18.3, 16.7, 15.1

③ Calculation speed

Assuming that the service point is near the center line and the lateral distance is ignored, it can be seen through simple calculation that the distance from the ball under the inner corner line (red line on the figure) to the border of the opposite service line is about 18.3 meters, the outer corner line (yellow line on the figure) is about 18.8 meters, and the middle line (orange line on the figure) is about 18.4 meters. Since the landing point of the general service is mainly in the back half of the service area near the service line, the reference distance of the main landing point is also marked on the figure.

Taking Daniel Elahi Galan as an example, the ball's course is middle and the landing point is BW, so the horizontal flight distance of the ball is estimated to be about 15.2 meters. According to the attachment, it can be determined that the movement time of the ball at this time is 35 seconds.

With the time and distance, v=s/t is used to calculate the average horizontal speed of the service during flight.

If the landing point is BC and the flight distance reference value is 16.8 meters, the average horizontal speed = 15.2/16*35=33.25(m/s), and the hitting speed is 33.25*3.6=119.7km/h.

If the landing point is C, the movement time of the ball is 33 seconds, 18.8/16*33=38.775(m/s), and the hitting speed is 53.75*3.6=139.59km/h.

If the drop point is w or b or wb, the same calculation of serving speed is omitted here.

2.3 Establishing the Formula of Fortune Calculation

2.3.1. Feature Engineering

Momentum feature extraction: According to the attachment, statistically calculate the momentum of each player. The positive aspect of the positive aspect is the number of points scored in front of the net, the number of forehand wins, and the number of untouchable winning serves played in the match. The negative aspect of the positive aspect is the number of unforced errors of the ball. The calculation of fortune needs to be based on the total chance, which is selected as the total number of shots hit by two players in this point.

Other feature selection: Consider other characteristics that may affect a player's performance, such as the number of serves a player has (serving increases the winning percentage), the number of serves a player has saved, the number of breaks a player has made, the number of serve wins a player has made, the number of forehand wins a player has won a backhand, the number of times a player has hit an untouchable winning serve, the number of times a player has been near the net at some point in the point, The player wins this point at the net, the distance the player runs inside the point (meters), the speed of the serve (miles per hour; Miles per hour), the number of double faults by the player, the number of unforced errors by the player.

2.3.2 Establish a Simple and Efficient Momentum Calculation Formula

The formula is established: Momentum = (number of times to end a point)/(chance to end a point).

The number of points that end a point includes the number of points at the net, the number of forehand points, the number of winners, minus the number of double faults.

The chance to end a point consists of indicating the total number of strokes played by the two players in that point.

Today's top 100 opponents in the tennis world are ranked in a super first-class position. Under normal circumstances, there should not be such a wide gap between them, but between a given two opponents,

the style of play is often more important than big data. This paper calculates the frequency of players' attempts to actively end the score in a game, which is finally reflected by horoscope scoring horoscope = 'number of times to end a point'/' chances to end a point '. Average luck = (number of points won at the net + number of forehand wins + number of times a player has hit an untouchable winning service ball - number of times the opponent has made a mistake on a better return)/total number of shots.

1) When a player hits a winning point, unforced error, or forced error, we add up the number of shots and call them the "number of points that end a point."

2) In the service game, we count the number of rounds as the denominator, the number of shots the player hits on his own court. It adds up to "chances to end the point."

If we divide "the number of terminations" by "the chance of terminating", we get a decimal between 0 and 1. As the number increases, it indicates that the player's fortune is stronger.

The following table shows the horoscope score data for 62 players in 31 matches in the dataset. Because this tennis analysis source is based on data from each shot, there are limits to predictions. Therefore, this calculation still needs to be improved, mainly for players with similar playing styles must supplement other models to make predictions.

w-1302,Alexander Zverev's predictive score is 34.4238347, and mean score is 0.171262859; Matteo Berrettini's predictive score is 37.79880952,and mean score is 0.188053779 ,Matteo Berrettini won.

2023-w-1303, Frances Tiafoe's predictive score is 8.336772498 ,and mean score is 0.06221472,Grigor Dimitrove's predictive score is 30.99818841 ,and mean score is 0.231329764,Grigor Dimitrove won,etc...

The reason for the inaccurate prediction in 13 of 31 matches is that this prediction is not suitable for the match between players with more strength differences. n order to improve the accuracy of prediction, various factors should be considered comprehensively in the prediction of different strength players. Next, a fuzzy judgment prediction model based on feature extraction is established.

3. Building a Horoscope Improvement Model

3.1 Multilevel Fuzzy Comprehensive Evaluation Principle

In the first step, the factor set U={u1,, u₂,... ,un} divided by some attribute into s subfactor sets U1, U2,... Us where Ui={Ui1, Ui2,... Uis} satisfy.

①n1+n2+... +ns,=n,

②U1∪U2∪⋯∪Us=U,

③ For any i≠j,Ui∩Uj= diameter.

The second step is to make a comprehensive evaluation for each factor set Ui, V={v1,v2,... ,vm} is the comment set, and the weight distribution of each factor in the Ui relative to V is Ai=[ai1,ai2,…,ain].

If Ri is a single factor evaluation matrix, the first order evaluation vector is obtained.

Bi = Ai. Ri = [bi1, bi2,..., bim], i= 1, 2,... ,s.

Third, consider each Ui as a factor, denoted as:

K={u1',u2',… ,us'}.

R=[B1',B2',...Bs ']

Each Ui,as A part of U, reflects a certain attribute of U, and can be assigned a weight according to their importance A=[a1,a2,...,as,], thus obtaining the second-order evaluation vector.

B=A*R = [b1,b2,…,bm].

If each sub-factor set Ui(i=1,2,.,s) contains more factors, the Ui can be further divided, so there are three levels of evaluation model:

Table 1. Fuzzy judgment index set

Primary index and	secondary index	evaluation
Past strength	serves	0,1
	Number of guaranteed packets	0,1
	Number of breaks	0,1
	Number of successful rounds	0,1
	Number of game-winning serves,	0,1
	Number of forehand wins	0,1
	Number of backhand wins	0,1
Positive psychological suggestion	p_distance_run	After normalization0-1
	speed_mph	After normalization0-1
	p_net_pt	0,1
	p_net_pt_won	0,1
Negative psychological suggestion	p_double_fault	0,1
	p_unf_err	0,1

3.2 .Model Calculation:

The following figure shows the results of real-time strength horoscope comparison between players 1 and 2 in 2023-wimbledon-1301 match.

Table 2. Instantaneous horoscope prediction

Nicolas Jarry Instantaneous horoscope	Carlos Alcaraz Instantaneous horoscope
0.156559296	0.11799805
0.012280879	0.570447381
0.179360655	0.305171815
0.285714286	0.824365415
0.000314357	0.696843374
0.149717746	0.261558305
0.032717892	0.706672501
0.604615141	0.296456042
0.04562177	0.929572751
0.051019183	0.595664782
0.700770154	0.012334755
0.459930716	0.184955224
0.306978846	0.198321962
0.722271882	0.022744136
0.572291422	0.007247335
0.254806602	0.154157783
0.572012658	0.011183369
1.013064202	0.032396588
0.000809707	0.712880299
0.064982348	0.607780896
0.162232963	0.427499579
-0.081327006	0.659119915
91.50222639	95.45087865

As calculated 95> 91,Carlos Alcara won, as the actual result, the full 1301 game horoscope comparison chart below, generally speaking, the strength of the opponent more stalemate.
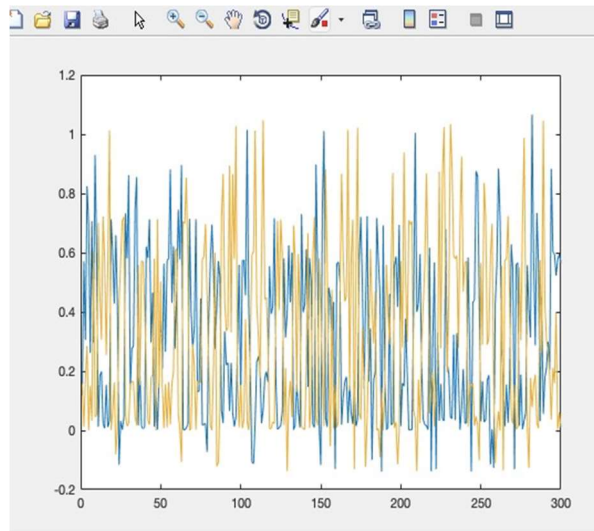

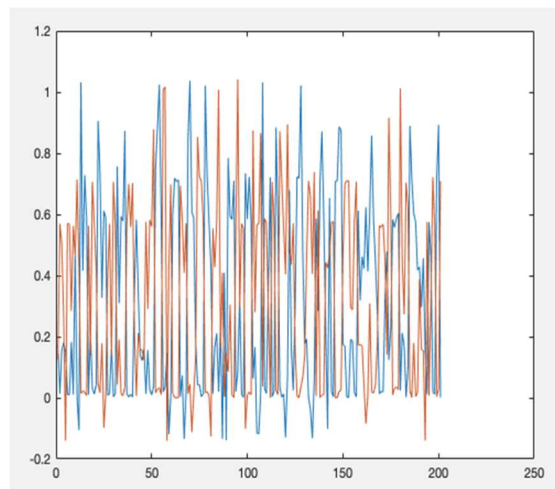**Figure 2.** 2023-wimbledon-1302, the Momentum of players 1

Figure 3. 2023-wimbledon-1302, the Momentum of players 2

Acknowledgments

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