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Tennis match performance prediction applied research based on normalization grey model

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ABSTRACT

Tennis challenges athlete's endurance and physical quality, make correct prediction on performance can make good evaluation on a tennis player's individual development. The paper makes prediction on tennis player's sporting performance, firstly establishes normalization model, uses data to express turn-based tennis performance; secondly establishes grey model, and makes prediction on data after normalization. To tennis match, the paper defines first round elimination as 1, second round elimination as 2, the third round elimination as 3, final sixteen as 4, the final eight as 5, top four as 6, finals as 7, champion as 8, it gets participating performance average coefficient, and combines with established data to make comparative prediction on tennis performance, it defines feasibility of grey prediction performance.

KEYWORDS

Grey model;
Normalization;
Tennis match;
Discrete sequence.

PREFACE

Tennis appeared as indoors tennis as earliest, modern tennis formally started in 1873, after that a lot of excellent tennis players also emerged. Tennis is the same as other sports events, if it can well predict on the event and performance, which is a good evaluation on individual tennis development and local tennis.

Among them, lots of scholars have also made efforts and got achievements, which provides beneficial conditions for scholars from all circle of society researching, and provides impetus for tennis development. Forsyth and Schlenkey randomly selected 122 tennis players and made investigation, he pointed out that loser made fewer efforts as well as ability aspect factor attribute relative to winner, and particularly presented female's losing was mainly attributed to one's own causes and denied the importance of luckiness; Qiu Yi-Jun in tennis psychological factor analysis, she revealed psychological ability in tennis match was main factor to win the match, to tennis, due to lack of embodiment and clarity, researches on complicated psychological factors were even fewer; Wang Fang proposed tennis players' special techniques features and evaluation system, from which his weight was got by adopting expert and experiences as well as other methods, which had stronger objectivity; Wang Ni created tennis special performance evaluation model based on neural network, and applied multiple linear regression method to predict tennis performance, in addition he also provided correct schemes for improving tennis players' qualities levels; Yin Hang put forward physical quality shape and

technical researches as well as analysis of different levels' tennis players. Mark and others selected 59 people as tennis objects, their result showed that different performance athletes had no extremely obvious differences, but most of success people were contributed to stability and controllability.

The paper on the basis of previous research results, it analyzes tennis players' performance influence factors, discusses grey model algorithms, grey prediction system was firstly put forward by Chinese Professor Deng Ju-Long in 1979, and with "grey system" establishment, it has prompted an immediate and strong reaction at home and abroad, and rapidly be applied into agriculture, biology, water conservancy, society, weather and so on. Regarding apply grey system into sports, it is well evaluating on athlete performance and shows obvious advantages in each aspect of sports.

MODEL ESTABLISHMENTS

Tennis has been rapidly developed since modern times, many national people are infatuated with it, and tennis basic motion is as Figure 1 show.

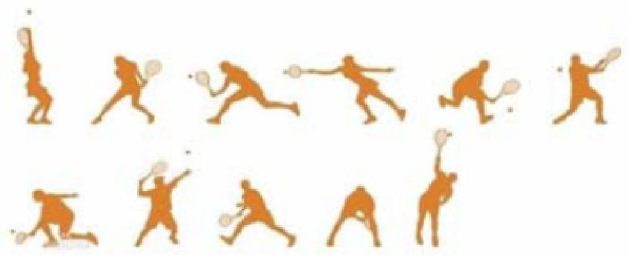

Figure 1: Tennis basic motion

To further analyze tennis, it establishes grey prediction model, its theory is as following.

Data normalization

Normalization is to convert data with different magnitude orders sizes into data that possesses comparability and with same dimension and same magnitude order. For data normalization model's main methods, that are linear function method, logarithmic function method, arc cotangent function method and so on.

Linear function method, to sample data $x(n)$, n=1, 2, ……, N, the sample data after normalization can adopt three expression methods that are respectively max-min method, mean method and median method. Max-min method is used to normalize sample data to the range [0, 1], mean method is used to normalize data into any range, but maximum value and minimum value symbols cannot simultaneously change; median method is used to normalize sample data to range [-1, 1], three kinds of methods formula are respectively as following show.

$$y(k) = (x(k) - \min(x(n)))/(\max(x(n)) - \min(x(n))), k = 1, 2, \cdots, N$$

$$y(k) = A\frac{x(k)}{\bar{x}}, k = 1, 2, \cdots, N \quad , \quad \bar{x} = \frac{1}{N}\sum_{i=1}^{N} x(i)$$

$$y(k) = \frac{x(k) - x_{mid}}{\frac{1}{2}(\max(x(n)) - \min(x(n)))}, \quad k = 1, 2, \cdots, N$$

$$x_{mid} = \frac{\max(x(n)) + \min(x(n))}{2}, \quad n = 1, 2, \cdots, N$$

Logarithmic function method, to sample data $x(n)$, n=1, 2, ……, N it has great data size, after normalization, the obtained sample data $y(n)$ is:

$$y(k) = \log_{10}(x(k)), k = 1, 2, \cdots, N$$

Norm method, to sample data $x(n)$, n=1, 2, ……, N, composed vector $\vec{X}$, after normalization, sample data $y(n)$ composed vector $\vec{Y}$, it can use formula to express as:

$$\overline{X} = \frac{\overline{X}}{\left\|\overline{X}\right\|_2} = \left(\frac{x_1}{\sqrt{\sum_{i=1}^{n} x_i^2}} \quad \cdots \quad \frac{x_2}{\sqrt{\sum_{i=1}^{n} x_i^2}} \right)^T$$

Different vectors' length or directions will be different, to vector, it can adopt 2 norm method to convert vector into unchanged direction and length as 1 unit vector.

Grey model establishment

Grey system is making researches on small information or information's uncertainties, and establishing grey system by examining partial information to correct describe position information.

Assume every time athlete measured performance is the athlete ability's representative faithfulness; Grey system GM(1, 1) model achieves prediction purpose based on multiple kinds of information.

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At first carry out data transformation, due to sub factor data with different dimensions that have no comparability, to ensure modeling result accuracy, it should proceed with data transformation and eliminate factor's dimension. Method is as following:

Ordered sequence: $x = (x(1), x(2), \cdots x(n))$

And then call map: $f : x \to y$, $f(x(k)) = y(k), k = 1,2,\cdots n$

It is sequence x to sequence y data transformation, its data transformation has:initialization transformation, mean transformation, percentage transformation, multiple transformation, normalization transformation, maximum range transformation, interval values transformation and so on. Here adopts initialization transformation:

$$f(x(k)) = \frac{x(k)}{x(1)} = y(k), k = 1,2,\cdots n \text{且} x(1) \neq 0$$

That is f initialization transformation. Carry out initialization transformation on matrix A, and adopts matrix formal transformation.

And fitting obtained model is time sequence differential equation of first order. Grey system is establishing differential equation on discrete sequence: $\frac{dx}{dt} + ax = \mu$

By derivative definition, it is clear: $\frac{dx}{dt} = \lim_{\Delta t \to 0} \frac{x(t + \Delta t) - x(t)}{\Delta t}$

When Δt region is 0, Δt approximately value unit is 1, then it has: $x(t+1) - x(t) = \frac{\Delta x}{\Delta t}$

Its discrete version is: $\frac{\Delta x}{\Delta t} = x(k+1) - x(k) = \Delta^{(1)}(x(k+1))$

Assume $\mathrm{X}^{(0)} = \left(x^{(0)}(1), x^{(0)}(2) \cdots x^{(0)}(3)\right)$ is non-negative sequence, and make one time accumulating on $X^{(0)}$, it gets generation sequence is: $\mathrm{X}^{(1)} = \left(x^{(1)}(1), x^{(1)}(2) \cdots x^{(1)}(3)\right)$, from which $x^{(1)}(k) = \sum_{i=0}^{k} X(i)$, $x^{(0)}(k) + az^{(1)}(k) = b$ simplifies and gets: $x^{(0)}(k) = \beta - \alpha x^{(1)}(k-1)$, from which:

$$\beta = \frac{b}{1+0.5a}, \ \alpha = \frac{a}{1+0.5a}$$

$$\begin{bmatrix} x^{(0)}(2) \\ x^{(0)}(3) \\ \vdots \\ x^{(0)}(n) \end{bmatrix} = \begin{bmatrix} -\frac{1}{2}(x^{(1)}(1) + x^{(1)}(2)) & 1 \\ -\frac{1}{2}(x^{(1)}(2) + x^{(1)}(3)) & 1 \\ \vdots & \vdots \\ -\frac{1}{2}(x^{(1)}(n-1) + x^{(1)}(n)) & 1 \end{bmatrix}$$

Let

$$Y = \begin{bmatrix} x^{(0)}(2) \\ x^{(0)}(3) \\ \vdots \\ x^{(0)}(n) \end{bmatrix}, B = \begin{bmatrix} -\frac{1}{2}(x^{(1)}(1) + x^{(1)}(2)) & 1 \\ -\frac{1}{2}(x^{(1)}(2) + x^{(1)}(3)) & 1 \\ \vdots & \vdots \\ -\frac{1}{2}(x^{(1)}(n-1) + x^{(1)}(n)) & 1 \end{bmatrix}$$

Grey prediction model test

According to posterior error test method, it tests grey prediction model as TABLE 1.

Solve one moment interval's time residual S_1 and original data S_2, according to posterior error ratio formula: $c = \frac{S_1}{S_2}$

Solve error probability P, according to formula: $P = P\left\{\left|\varepsilon_{(1)}^{(0)} - \bar{\varepsilon}\right| < 0.6745 S_2\right\}$, from which $\bar{\varepsilon}$ is

TABLE 1: Precise test grade test table

Prediction precise grade	P	C
Good	> 0.9	< 0.35
Qualified	≥ 0.8	< 0.45
Barely	≥ 0.7	< 0.5
Unqualified	< 0.7	≥ 0.65

mean value of residual. According to C value and P value, test corresponding precise test grade test table.

Tennis performance solution

According to above model, the paper collects Henin (Belgium) performance from 2006 to 2008, and makes prediction.

Define participating performance coefficient: it defines first round elimination as 1, second round elimination as 2, the third round elimination as 3, final sixteen as 4, the final eight as 5, top four as 6, finals as 7, and champion as 8.

According to above definition, it makes summary of Henin performance and gets participating performance average coefficient TABLE 2.

By TABLE 2, it can get Henin performance trend chart as Figure 2 shows.

The paper utilizes MATLAB software and gets performance fitting curve Figure 3.

According to Figure3, it gets future development performance is 6.768, 6.7791, 6.7902, 6.8013, 6.8124, 6.8236, 6.8348, 6.846

TABLE 2 : Henin (Belgium) performance from 2006 to 2008

Year	Participating performance Average coefficient	Year	Participating Performance Average coefficient
2006.1	6.5	2007.5	7.5
2006.1	5.3	2007.6	7.3
2006.2	7.2	2007.6	7.2
2006.3	5.3	2007.8	5.9
2006.5	2.6	2007.8	8.3
2006.5	5.7	2007.8	8.3
2006.5	6.3	2007.11	8.3
2006.6	7.4	2007.11	8.3
2006.6	7.4	2007.11	8.3
2006.8	6.8	2008.1	8.3
2006.8	7.5	2008.1	5.4
2006.11	6.6	2008.2	7.4
2007.2	5.4	2008.2	5.4
2007.2	7.5	2008.2	5.2
2007.3	7.5	2008.3	5.4
2007.4	6.3	2008.5	3.1

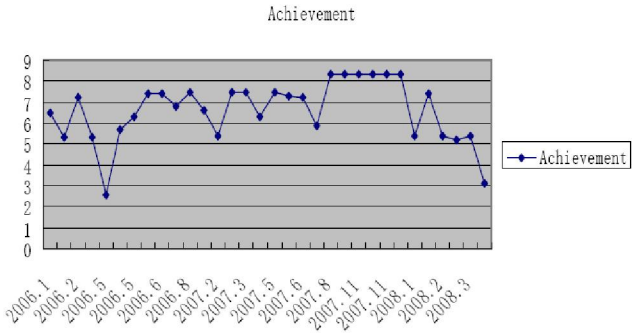

Figure 2 : Performance trend chart

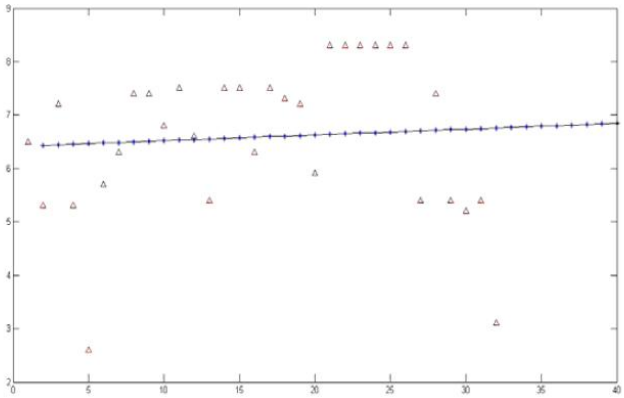

Figure 3 : Fitting performance graph

CONCLUSIONS

Tennis match performance is turn-based, therefore, the paper establishes data normalization model, uses data to express turn-based tennis performance, secondly the paper establishes grey prediction model, makes prediction on data after normalization, and combines with established data to make comparative prediction on its future development performance and check feasibility of grey prediction performance. Grey prediction system is grey system's important part. Grey system has got remarkable achievements in multiple fields, multiple aspects, it solves multiple important problems. To future exploration, it can make effective prediction on future information, is an effective way that human race reforms society. But due to data imperfection, it generates lots of systems. Such as fuzzy mathematics as well as rough theory, it researches imperfect information in different ways.

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