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Research Article

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World men sprint event development status research based on grey theory

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ABSTRACT

Next Olympic Games prediction problem is always the hot pot that attracts correlation researchers' attention. By SPSS mathematical statistics method, test and handle with previous Olympic Games men 100m first performance, establish grey GM(1, 1) prediction model, prediction result is 9.71s, and through testing on residual value and ultimate ratio deviation value, it gets that the prediction result is relative correct. In research, it combines with actual, select recent several sessions' performance data to make prediction again, result is 9.49s, comparing with first prediction result, and it is more accurate and conforms to practice. Therefore, next session Olympic Games men 100m performance is within the range 9.49s-9.71s. The model has the advantages of small relative errors from prediction results and high precise.

Key words: GM (1, 1) grey model, Men 100m, Performance prediction, Olympic Games

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INTRODUCTION

Sprint has a profound history, is one of oldest sport events and competitive events; 100m is an event that best represents excellent athletes' physical ability and speed. 100m race competition process is quite short, fighting process is very fiercely, therefore it is athletics all competitions most stimulating, fiercely and wonderful competition event as well as possessing ornamental values in competitive sport events, it is also the athletics competitive event that people hold it to the highest expectations for a long time [1-3]. Throughout world sprint development, under the situation that world 100m competitive levels are constant increasing, recently years world records are frequently broken through, which let people start to think about men 100m performance extremes and daily training methods as well as ways [4-6]. For future 100m competitive performance prediction, it also arouses people with full curiosity and hopefulness; relative correct prediction on competitive performance can provide a kind of effective reference for athletes' training [7].

Wu Ye-Hai, Yu Bao-Ling , Lou Lan-Ping in " Chinese university students' athletic competition performance and ranking prediction analysis research[1]", they established competition performance and ranking prediction model, and applied optimal prediction model and fluctuation difference computation formula, so that predicted next Universidad athletic competition performance and ranking. Yang Feng, in "National games athletic performance development trend analysis and predication research [2]", he adopted document literature, comparative analysis, mathematical statistics and grey prediction method carrying out prediction on national games athletic performance development trend. Liu Xi-Ping in his "100m extreme speed prediction [3]" applied extreme thoughts predicting human race 100m extreme speeds.

Adopt grey prediction model GM(1, 1) model , it can make prediction on next session Olympic Games men 100m performance, utilize recent several sessions Olympic Games performance relative correct predicting next session performance. The model fully uses correlation data [4], prediction result relative errors are small, and its accuracy is high.

100M PERFORMANCE EVALUATION GREY GM(1, 1) PREDICTION MODEL

Grey system theory main task is according to specified grey system modeling data behavior features, fully exploit and utilize fewer data's implicit information and fuzzy information, find out mathematical relationships between its own elements or elements themselves. Common method is using discrete model, establish model that analyzes according to time subsection [8].

Olympic Games men 100m performance in year 1952 to 2012 as Table 1 shows:

Table 1: Olympic Games men 100m performance in year 1952 to 2012(unit s)

Year	1952	1956	1960	1964	1968	1972	1976	1980
Performance	10.4	10.5	10.2	10.0	9.95	10.14	10.06	10.25
Year	1984	1988	1992	1996	2000	2004	2008	2012
Performance	9.99	9.92	9.96	9.84	9.87	9.85	9.69	9.63

According to above data, draw out previous Olympic Games men 100m performance curve graph, as following Figure 1 shows:

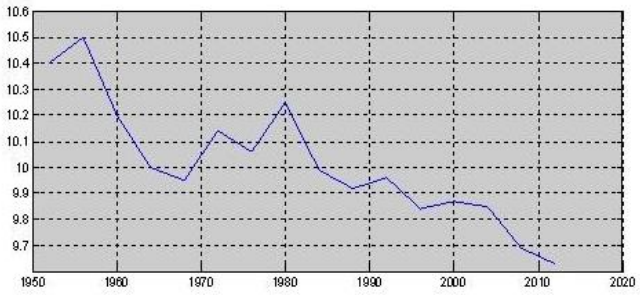

Figure 1: Previous Olympic Games 100m performance trend graph

From previous Olympic Games 100m performance trend line Figure 1, it is clear intuitively reflecting men 100m performance time is trending down that men100m performance is trending up. The best performance is 9.63s in 2012 that created by Jamaica player Bolt, by far nobody can go beyond. During year 1972 to 1984, performance largely fluctuation had appeared, but it couldn't affect world men 100m performance rising trend.

(1)Data handling and test

At first, in order to ensure modeling methods' feasibility, it needs to carry out necessary known data series testing process.

For 100m competition performance, establish time series as following:

$$x^{(0)} = \left(x^{(0)}(1),\ x^{(0)}(2),\cdots x^{(0)}(16)\right) = (10.4,10.5,10.2,10.0,9.95,10.14,10.06,10.25,9.99,9.92,9.96,9.84,9.87,9.85,9.69,9.63)$$

Calculate series ultimate ratio:

$$\lambda(k) = \frac{x^{(0)}(k-1)}{x^{(0)}(k)}, k = 2,3,\cdots,16 \tag{1}$$

Input data into formula (1) , it can get:

$$\lambda = \left(\lambda(2),\ \lambda(3),\cdots,\ \lambda(16)\right) = (0,0.99,1.03,1.02,1.01,0.98,1.01,0.98,1.03,1.01,1.00,1.01,1.00,1.00,0.99,1.03)$$

If all ultimate ratios $\lambda(k)$ can accommodate and cover within the range of $\left(e^{-\frac{2}{n+1}}, e^{\frac{2}{n+2}}\right)$ that is $(0.8890,1.1175)$, then series model series $x^{(0)}$ can be regarded as $GM(1,1)$ data to implement grey prediction. By testing, all ultimate ratios $\lambda(k) \in (0.8890,1.1175)$, so selected data can establish the model.

(2)Establish model:

Make once accumulation generating series: $x^{(1)}=\left(x^{(1)}(1),\ x^{(1)}(2),\cdots,\ x^{(1)}(16)\right)=(10.4,20.9,\cdots,160.42)$

Among them: $$x^{(1)}(k)=\sum_{i=1}^{k}x^{(0)}(i),(k=1,2\cdots n)$$

Then define $x^{(1)}$ grey derivative as: $d(k)=x^{(0)}(k)=x^{(1)}(k)-x^{(1)}(k-1)$

Let $z^{(1)}$ to be series $x^{(1)}$ proximate average value number [5], which is: $z^{(1)}(k)=0.5x^{(1)}(k)+0.5x^{(1)}(k-1),k=1,2,3\cdots n$

Then $z^{(1)}=\left(z^{(1)}(2),z^{(1)}(3),\cdots z^{(1)}(16)\right)$

Define grey differential equation model [5] as $d(k)+az^{(1)}(k)=b$, that is: $x^{(0)}(k)+az^{(1)}(k)=b,(k=2,3\cdots n)$

From which $x^{(0)}(k)$ is called grey derivative [5], a is called development coefficient [5], $z^{(1)}(k)$ is called white background value [5], b is called grey actions [5].

Corresponding the whiten differential equation [5] is:

$$\frac{dx^{(1)}}{dt}+ax^{(1)}(t)=b \tag{2}$$

Input $k=2,3\cdots 16$ into formula (2), it has: $\begin{cases}x^{(0)}(2)+az^{(1)}(2)=b\\x^{(0)}(3)+az^{(1)}(3)=b\\\cdots\cdots\\x^{(0)}(n)+az^{(1)}(n)=b\end{cases}$

Let $Y=\left(x^{(0)}(2),x^{(0)}(3),\cdots,x^{(0)}(16)\right)^T$, $u=(a,b)^T$, $B=\begin{bmatrix}-z^{(1)}(2) & 1\\ -z^{(1)}(3) & 1\\ \vdots & 1\\ -z^{(1)}(16) & 1\end{bmatrix}$, is called Y the data vector[5], B is data series[5], u is parameter vector[5], then $GM(1,1)$ can be expressed as matrix equation $Y=Bu$.

By least square method, it can solve: $\hat{u}=(a,b)^T=\left(B^TB\right)^{-1}B^TY$

Utilize MATLAB software calculating a,b values, result is: $\begin{cases}a=0.0036\\b=10.3166\end{cases}$, Input a,b into formula (2), it gets:

$$x^{(1)}(k+1)=\left(x^{(0)}(1)-\frac{b}{a}\right)e^{-ak}+\frac{b}{a}=2878.99-2868.59e^{-0.0036k} \tag{3}$$

Solve generated series value $\hat{x}^{(1)}(k+1)$ as well as model reducing value $\hat{x}^{(0)}(k+1)$

Let $k=1,2,\cdots 15$, by formula (4), it can calculate $\hat{x}^{(1)}$, value $\hat{x}^{(1)}(1)=\hat{x}^{(0)}(1)=\hat{x}^{(0)}(1)=10.4$,

by $\hat{x}^{(0)}(k)=\hat{x}^{(1)}(k)-\hat{x}^{(1)}(k-1)$., value $k=2,3,\cdots 16$, it can get $\hat{x}^{(0)}$:

$\hat{x}^{(0)}=(10.4,10.31,10.27,10.23,10.20,10.16,10.12,10.08,10.05,10.02,9.98,9.94,9.91,9.87,9.80,9.76)$ It predicts the 31 session Olympic Games performance is 9.71s by this model.

(3)Model test: Test on grey system 100m performance prediction models

1) Residual test [5]: Let residual to be $\varepsilon(k)$, computation formula: $\varepsilon(k)=\dfrac{x^{(0)}(k)-\hat{x}^{(0)}(k)}{x^{(0)}(k)},k=1,2,\cdots n$

If $\varepsilon(k)<0.2$, then it can be thought meet normal requirement, if $\varepsilon(k)<0.1$, then it is thought that meet higher requirement.

2) Ultimate ratio deviation value test [5]: $\rho(k)=1-\left(\dfrac{1-0.5a}{1+0.5a}\right)\lambda(k)$

If $\rho(k)<0.2$, then it can be thought meet normal requirement, if $\rho(k)<0.1$, then it is thought that meet higher requirement. Test each year 100m performance residual and ultimate ratio deviation value as Table 2 shows:

Table 2: Every year performance residual and ultimate ratio deviation value

Year	Actual value	Predicted value	Residual value	Ultimate ratio deviation value
1952	10.4	10.4	0	0
1956	10.5	10.31	0.0181	0.0131
1960	10.2	10.27	-0.0069	-0.0257
1964	10.0	10.23	-0.0230	-0.0163
1968	9.95	10.2	-0.0251	-0.0014
1972	10.14	10.16	-0.0020	0.0223
1976	10.06	10.12	-0.0060	-0.0043
1980	10.25	10.08	0.0166	0.0221
1984	9.99	10.05	-0.0060	-0.0223
1988	9.92	10.02	-0.0101	-0.0034
1992	9.96	9.98	-0.0020	0.0076
1996	9.84	9.94	-0.0102	-0.0086
2000	9.87	9.91	-0.0041	0.0066
2004	9.85	9.87	-0.0020	0.0016
2008	9.69	9.80	0.0131	0.0146
2012	9.63	9.76	-0.0177	-0.0306

From Table 2 data, it is clear that residual values $\varepsilon(k)$ all less than 0.1, predicted values meet higher requirement; Ultimate ratio deviation values $\rho(k)$ all less than 0.1, predicted values meet higher requirement. To sum up, the model predicted values are precise.

Predicted 100m performance in year 1952 to 2012 by using this model and actual values comparison chart, as Figure 2 shows:

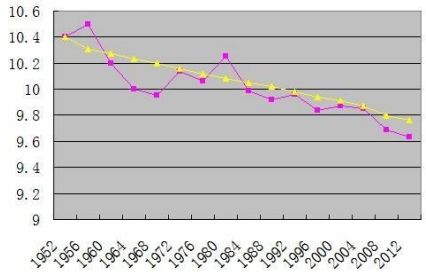

Figure 2: Predicted value and actual value comparison chart

From Figure 2, it is clear that Olympic Games from year 1952 to 1984 100m performance have larger fluctuation, it

fluctuates in $(10.5,10.0)$ time phase, but basically it is relative stable, predicted values are in relative stable smaller state. No matter considers from national economic development levels or athletes' training as well as protective extents, predicted values conform to the actual status. In year 1984 to 2008, these sessions Olympic Games performances are basically trending stable with small fluctuation, predicted values basically get close to actual values. Taken together, predicted values and actual values average relative error is 0.55%.

According to above prediction results, it is clear that with modern science and technology development and increasing economic development, athletes' levels are constant increasing and improving, therefore, apply recent years' performance to predict future levels will more get close to actual. So reconstruct model to predict recent sessions' Olympic Games performance.

By above analysis, it can get that performance from year 1984 to 2012 tends to stable, data is well, so adopt data from year 1984 to 2012 to predict, prediction result as Table 3 shows:

Table 3: Each year performance residual and ultimate ratio deviation value

Year	Actual value	Predicted value	Residual	Ultimate ratio deviation value
1984	9.99	9.99	0.0000	1.0000
1988	9.92	10.02	-0.0101	-0.0136
1992	9.96	9.96	0.0000	-0.0025
1996	9.84	9.89	-0.0051	-0.0188
2000	9.87	9.83	0.0041	-0.0035
2004	9.85	9.77	0.0081	-0.0086
2008	9.69	9.63	0.0062	-0.0231
2012	9.63	9.51	0.0125	-0.0128

By testing, both residual values and ultimate ratio deviation values meet requirements, average relative error is 0.20%, which is 0.55% smaller than above average relative error, more accurate predict the result.

Predicted 100m performance in year 1984 to 2012 by using this model and actual values comparison chart, as Figure 3 shows:

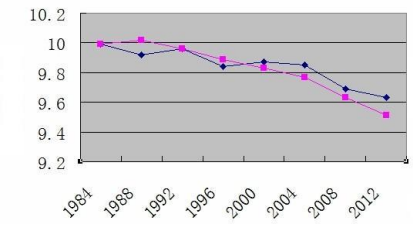

Figure 3: Predicted value and actual value comparison chart

From Figure 3, it is clear that predicted value and actual value change tendency are relative consistent and basically match in values , it can better reflect 100m competitive development tendency that 100m performance is constant updating , speed is gradually increasing.

Predicted performance at this time is 7.49s, which is smaller than predicted result by using whole data. To sum up, next session Olympic Games men 100m performance is within the range 9.49s-9.71s.

CONCLUSION

Utilized grey prediction model GM (1, 1), established discrete each group data correlations, more correctly predicted next session Olympic Games men 100m performance, the more precise prediction result is helpful for nation and sports bureau making some more strengthen training plans, as we can learn other country athletes some strengthen training methods, constantly require and encourage athletes to make more improvements in speed with predicted performance. But sprint is a kind of strenuous exercise , it is strict with human body each indicator, based on the predicted result, 100m performance may also exists extreme value, because people heart beating speed is limited. Under the social backgrounds of science and technology development, 100m competition world record surely has extreme speed limits; from the perspective of mathematics, 100m competition world record will be a monotonic decreasing and with bound, non-negative data, which surely has a limit. Therefore, for 100m performance predicted result, it can provide good reference for every level athlete's daily training.

Grey prediction model, can fully make use of discontinuous discrete data to establish data correlations that adapts to

less information conditions analysis and prediction, which possesses advantages as less load data, no need to consider data distribution, no need to consider data change tendency, easy operation, high predicted precise, convenient for testing. Grey prediction model can correctly predict population, catastrophe and outliers prediction, numbers of traffic accidents and other problems prediction; it can also apply into industry, agriculture, ecology, market economy and other multiple fields, it has wide application ranges. Its other each application field needs to be further researched and improved by us.

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