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Grey prediction model-based men's 100m freestyle Olympic Games performance prediction research

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ABSTRACT

Swimming is one of modern people favorite indoors events after work, meanwhile it is also Olympic Games important competition event. To improve men's 100m freestyle swimming level, the paper uses grey GM (1, 1) prediction model, establishes performance prediction model, and makes prediction on Chinese men's 100m freestyle performance in the 31st Olympic Games. Make use of grey prediction to make correlation analysis of performance development influence factors. And establish differential equation model by analyzing original data, it gets performance development trend status. And it further gets that Chinese men's 100m freestyle will get result as 47.92s in the 31st Olympic Games. By prediction men's 100m freestyle performance, it analyzes Chinese men's swimming performance development trend, it finds that Chinese and other swimming powers gap is still very big. Chinese athlete development still keeps larger paces with human body extremity, which still needs to increase athlete daily training's intensity of training.

Key words: Grey GM (1, 1), performance prediction, correlation analysis, differential equation

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INTRODUCTION

Swimming divides into competitive swimming and synchronized swimming. Swimming can make muscle balanced develop; strengthen body protection ability against cold. In addition, swimming can also exercise people's heart and lung functions, promote human body metabolism, lose weight and body building [1-3]. It is one of people favorite indoors events after work. Meanwhile swimming is also Olympic Games important competition event [4-6].

Competitive swimming has already become nowadays one of important sports events by years' developing, is an important symbol of country's competitive sports level high-low. In Olympic Games events, its golden medals ranks the second that is only second to athletics, so there is a word "Win athletics and swimming can control the world". However, Chinese swimming event overall strength is relative weak by comparing with other participated events in Olympic Games, especially for men's swimming events, which has certain gap with foreign swimming powers [7-10]. Research shows that Chinese swimming events contribution rate to Olympic Games'toal medals amount is quite low. Chinese swimming events performance in sports performance totality is lower, improve Chinese swimming performance will promote Chinese Olympic Games total performance. Therefore explore Chinese and foreign men's swimming performance development trend, find out Chinese men's swimming performance and Olympic Games performance differences and advantages are particularly urgent.

Competitive swimming according to swimming postures, it divides into: freestyle、backstroke、breaststroke and butterfly stroke; according to distance, it divides into men's freestyle 50m、100m、200m、400m、1500m; men's backstroke 100m、200m; men's breaststroke 100m、200m; men's butterfly stroke 100m、200m; men's medley stroke 200m、400m; men's freestyle relay 4*100m、4*200m; men's medley relay 4*100m. Details can refer to Table 1:

Table 1: Olympic Games Men's competitive swimming events table

Swimming types	Competition events
freestyle	50m、100m、200m、400m、1500m
backstroke	100m、200m
breaststroke	100m、200m
butterfly stroke	100m、200m
medley stroke	200m、400m
freestyle relay	4*100m、4*200m
medley relay	4*100m

The paper takes men's first performances during 21st ～30th Olympic Games as research objects, based on multi-dimensional grey GM(1, 1,)model, it establishes MATLAB grey model software program, predicts the 31st Olympic Games' Chinese and foreign men's swimming performances to analyze that provides references for China making Olympic Games strategies.

PERFORMANCE PREDICTION MODEL ESTABLISHMENT AND SOLUTION

Grey prediction model

Grey prediction method is a kind of method that predicting on system with uncertain factors. Grey system is a system between white system and black system.

Grey model (GM: Grey Model) can excavate known data column inherent law, and on this basis, it can use less data and time series line features. Grey prediction identifies system factors development trends difference degree that is making correlation analysis to do generation processing with original data so as to look for system changing rules, it generates stronger rules data sequence, and then establishes corresponding differential equation model, further predict things future development trend status. It uses equal interval observed a series of quantity values that reflects prediction objects features to construct grey prediction model, predict future one moment feature quantity or the time arriving at one feature quantity. Research objects are men's first performance in 21st～30th Olympic Games swimming events, data is from Chinese Olympic Committee official website[1] and Wikipedia[2]. Partial performance is as Table 2 show:

Table 2: The 21st ～30th Olympic Games swimming events men's first performances

Event	The 21st session	The 22nd session	The 23rd session	The 24th session	The 25th session	The 26th session	The 27th session	The 28th session	The 29th session	The 30th session
50m freestyle				22.14	21.91	22.13	21.98	21.93	21.30	21.34
100m freestyle	49.99	50.40	49.80	48.63	49.02	48.74	48.30	48.17	47.21	47.52
200m freestyle	1:50.29	1:49.81	1:47.44	1:47.25	1:46.70	1:47.63	1:45.35	1:44.71	1:42.96	1:43.15
400m freestyle	3:51.93	3:51.31	3:51.23	3:46.95	3:45.00	3:47.97	3:40.59	3:43.10	3:41.86	3:40.14
1500m freestyle	15:02.40	14:58.27	15:05.20	15:00.40	14:43.48	14:56.40	14:48.33	14:43.40	14:40.84	14:31.02
100m Back stroke	55.49	56.33	55.79	55.05	53.98	54.10	53.72	54.06	52.54	52.16
200m Back stroke	1:59.19	2:01.93	2:00.23	1:59.37	1:58.47	1:58.54	1:56.76	1:54.95	1:53.94	1:53.41
100m breaststroke	1:03.11	1:03.44	1:01.65	1:02.04	1:01.50	1:00.65	1:00.46	1:00.08	58.91	58.46
200m breaststroke	2:15.11	2:15.85	2:13.34	2:13.52	2:10.16	2:12.57	2:10.87	2:09.44	2:07.64	2:07.28
100m butterfly stroke	54.35	54.92	53.08	53.00	53.32	52.27	52.00	51.25	50.58	51.21
200m butterfly stroke	1:59.23	1:59.76	1:57.04	1:56.94	1:56.26	1:56.51	1:55.35	1:54.04	1:52.03	1:52.96
200m Medley			2:01.42	2:00.17	2:00.76	1:59.91	1:58.98	1:57.14	1:54.23	1:54.27
400m Medley	4:23.68	4:22.89	4:17.41	4:14.75	4:14.23	4:14.90	4:11.76	4:08.26	4:03.84	4:05.18
4*100m Freestyle relay			3:19.03	3:16.53	3:16.74	3:15.41	3:13.67	3:13.17	3:08.24	3:09.93
4*200m Freestyle relay	7:23.22	7:23.50	7:15.69	7:12.51	7:11.95	7:14.84	7:07.05	7:07.33	6:58:56	6:59.70
4*100m Medley relay	3:42.22	3:45.70	3:39.30	3:36.93	3:36.93	3:34.84	3:33.73	3:30.68	3:29.34	3:29.35

According to collected data, take each session Olympic Games men's 100m freestyle first performance as an example, it draws curve graph of previous Olympic Games men's 100m freestyle performance. As Figure 1 show:

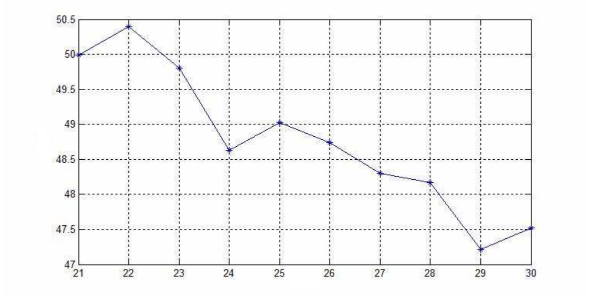

Figure 1: Previous Olympic Games men's 100m freestyle performance trend

From previous Olympic Games men's100m freestyle performance trend curve Figure 1, it can clearly and intuitionally reflect that overall time is in the declining trend that 100m freestyle performances are in the rising trend. Best performance is the 29th session 47.21s that is created by French player Alain Bernard.

Data processing and testing:
Firstly, in order to ensure modeling method feasibility, it needs to make essential testing process on known data sequence. Establish time sequence for men's 100m freestyle performance as following:

$$x^{(0)} = \left(x^{(0)}(1),\ \ x^{(0)}(2), \cdots x^{(0)}(10)\right) \tag{1}$$

Calculate sequence ultimate ratio:

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

If all ultimate ratio $\lambda(k)$ can be accommodated and covered in the range $\left(e^{-\frac{2}{n+1}}, e^{\frac{2}{n+2}}\right)$ that $(0.8890,1.1175)$, and then in data model, sequence $x^{(0)}$ can be used as model $GM(1,1)$ data to make grey prediction. By testing, all ultimate ratio $\lambda(k) \in (0.8890,1.1175)$, so selected data can establish the model.

Establish model:
Accumulated generate new sequence:

$$X^{(1)} = \left\{X^{(1)}(1), X^{(1)}(2), \ldots, X^{(1)}(10)\right\} \tag{3}$$

Among them

$$x^{(1)}(k) = \sum_{i=1}^{k} x^{(0)}(i), (k = 1,2\cdots 10) \tag{4}$$

Then define $x^{(1)}$ grey derivative as:

$$d(k) = x^{(0)}(k) = x^{(1)}(k) - x^{(1)}(k-1) \tag{5}$$

Let $z^{(1)}$ to be sequence $x^{(1)}$ adjoining mean values, that:

$$z^{(1)}(k) = 0.5x^{(1)}(k) + 0.5x^{(1)}(k-1),\quad k = 1,2,3\cdots 10 \tag{6}$$

Then $z^{(1)} = \left(z^{(1)}(2), z^{(1)}(3), \cdots z^{(1)}(10)\right)$

Define grey differential equation model as:

$$d(k)+az^{(1)}(k)=b \tag{7}$$

That

$$x^{(0)}(k)+az^{(1)}(k)=b,(k=2,3\cdots n) \tag{8}$$

Among them, $x^{(0)}(k)$ is called grey derivative, a is called development coefficient, $z^{(1)}(k)$ is called whitening background value, b is called grey action.

Corresponding whitening differential equation is:

$$\frac{dx^{(1)}}{dt}+ax^{(1)}(t)=b \tag{9}$$

Input $k=2,3\cdots 10$ into formula (9), it has: $\begin{cases} x^{(0)}(2)+az^{(1)}(2)=b \\ x^{(0)}(3)+az^{(1)}(3)=b \\ \ldots\ldots \\ x^{(0)}(n)+az^{(1)}(n)=b \end{cases}$

Let $Y=\left(x^{(0)}(2),x^{(0)}(3),\cdots,x^{(0)}(10)\right)^T$, $u=(a,b)^T$, $B=\begin{bmatrix} -z^{(1)}(2) & 1 \\ -z^{(1)}(3) & 1 \\ \vdots & 1 \\ -z^{(1)}(10) & 1 \end{bmatrix}$, call Y as data vector, B as data matrix, u as parameter vector, then $GM(1,1)$ model can be expressed as matrix equation: $Y=Bu$

By least square method, it can solve:

$$\hat{u}=(a,b)^T=\left(B^TB\right)^{-1}B^TY$$

Use MATLAB software to calculate a,b values, the result is:

$$\begin{cases} a=0.0036 \\ b=10.3166 \end{cases}$$

Input a,b into formula (9), it gets:

$$x^{(1)}(k+1)=\left(x^{(0)}(1)-\frac{b}{a}\right)e^{-ak}+\frac{b}{a}=2878.99-2868.59e^{-0.0036k} \tag{10}$$

Solve generated sequence value $\hat{x}^{(1)}(k+1)$ and model restored value $\hat{x}^{(0)}(k+1)$.

Let $k=1,2,\cdots 15$, by formula(10), it can calculate and get $\hat{x}^{(1)}$, take: $\hat{x}^{(1)}(1)=\hat{x}^{(0)}(1)=\hat{x}^{(0)}(1)=49.99$

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

$$\hat{x}^{(0)}=(49.99,50.23,49.82,49.32,49.02,48.79,48.33,48.21,47.22,47.48)$$

Use the model to predict that the 31st Olympic Games performance is $47.29s$.

Model test

Test on grey system predicted men's100m freestyle performance model:

1) Residual test: Let residual to be $\varepsilon(k)$, computational formula: $\varepsilon(k)=\frac{x^{(0)}(k)-\hat{x}^{(0)}(k)}{x^{(0)}(k)}, k=1,2,\cdots n$

If $\varepsilon(k)<0.2$, then it can be thought it arrives at normal requirements, if $\varepsilon(k)<0.1$, then it can be thought it arrives at higher requirement.

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

If $\rho(k)<0.2$, then it can be thought it arrives at normal requirements, if $\rho(k)<0.1$, then it can be thought it arrives at higher requirement.

Use MANLAB software; calculate previous men's 100m freestyle performance residual and ultimate ratio deviation value, result is as Table 3 show:

Table 3: Each session residual and ultimate ratio deviation value

Session	Actual value	Predicted value	Residual	Ultimate ratio deviation value
The 21st session	49.99	49.99	0	0
The 22nd session	50.4	49.81	0.01173	0.00131
The 23rd session	49.8	49.51	0.00582	-0.000257
The 24th session	48.63	49.13	-0.01028	-0.0163
The25th session	49.02	48.82	0.02631	0.0223
The 26th session	48.74	48.61	-0.01103	-0.0014
The 27th session	48.3	48.48	-0.03062	-0.0043
The28th session	48.17	47.92	-0.01083	-0.0223
The 29th session	47.21	47.86	-0.03021	-0.0034
The 30th session	47.52	47.64	0.002842	0.0076

From Table 3 data, it is clear: residual $\varepsilon(k)$ all is less than 0.1, predicted value arrives at higher requirements ; ultimate ratio deviation value $\rho(k)$ all is less than 0.1, predicted value arrives at higher requirements. To sum up, the model predicted value is very accurate.

Use the model to predict the 21st～30th Olympic Games men's 100m freestyle performance and actual value comparison figure, as Figure 2 show:

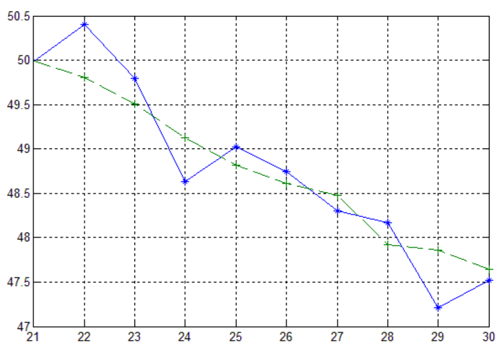

Figure 2: Each session Olympic Games men's 100m freestyle performance actual value and predicted value

From Figure 2, it is clear: the 21st～30th Olympic Games men's 100m freestyle performances are rather fluctuant, and go up and down in $(47,50.5)$ performance phase, but basically are relative stable. Predicted value is in relative stable little state.

No matter considering from world economic development level or athlete training and protection extent, predicted value conforms to practical status. In the 25th～30th session, it basically tends towards stability with little changes, predicted value basically gets closer to actual value. To sum up, predicted value and actual value average relative error is 0.55% .

CONCLUSION

Grey prediction model can make full use of discontinuous discrete data to establish data relations that is fit for analysis and prediction on the condition that information is less, it possesses advantages as little load data, no need to consider data distribution, ignoring data change trend, easy operation, high prediction precise and easier to test. Grey prediction model can correctly predict population amount, cataclysm and abnormal value prediction, the number of traffic accidents as well as other problems prediction; it can also apply into industry, agriculture, ecology, market economy and others many fields, it has widely application range. Its other kinds of application fields to be further researched and improved by us.

Make use of grey GM (1, 1) prediction model, establish discrete each group of data correlations, relative correctly predict the 31th Olympic Games men’s 100m freestyle performance. Such relative precise prediction result is beneficial to country and sports bureau to make some more intensified training plans, if we can learn from other countries players’ some intensified training methods, constantly require and stimulate players to make more improvements in speed with predicted performance.

But 100m freestyle is a kind of vigorous exercise; it is strict with people body each kind of indicators, on the predicted result basis, performance has also limit values, because people heart beating speed has limitations. In the background of science and technological development, competitive swimming world record also surely has limiting speed constraints, from the perspective of mathematics, competitive swimming world record will be a kind of monotone decreasing and bounded nonnegative data, it surely has a limit. Therefore, for men’s 100m freestyle performance predicted result, it can provide good references for each level athlete’s daily training.

The 31th Olympic Games each event performance will continue to improve steadily, though performance is constantly improving, it still keeps certain paces with human extremity, prediction shows that it will have above half Olympic Games swimming performance records to be broken in the next Olympic Games. And data shows Olympic Games swimming events have entered into a period of rapidly development.

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