The Gray GM(1.1) Prediction in Wheat Production of Shandong Province Based on the MATLAB

Qianqian Zhang^{1,a}, Jie Yang^{2,b}, Yingchun Zhang^{1,c}, Mingchuan Ji^{2,d,*}

¹School of Electrical Engineering and Automation, Qilu University of Technology,
Jinan, China

²Shandong Institute of Agriculture Sustainable Development
Jinan, China

^azhqq_520@163.com, ^bamber1026@163.com, ^czyc_10@126.com, ^djmc6668@163.com

Abstract—MATLAB is a kind of software which has powerful computing capabilities. This paper used the MATLAB software to computing the gray GM(1.1) prediction model, and establish the gray GM(1.1) prediction model based on historical data of production of wheat in Shandong Province. Through residual test, the prediction model is suitable for wheat prediction. This paper predicted the planting area, yield and output of wheat in Shandong Province from 2013 to 2015, and calculated the error range.

Keywords- MATLAB; gray GM(1.1); wheat production; predict

I. INTRODUCTION

Shandong province is one of the major wheat producing provinces. Wheat acreage was 14.0% of the country's total wheat acreage, total production accounted for about 16.8%. Shandong Province is not only one of China's main winter wheat producing areas, but also is one of the main producing areas of China's wheat yield and advantages. Forecasting for wheat production in Shandong Province, including its acreage, production and yield, has great significance to promote the development of modern agriculture industrial as well as establish and improve the modern agricultural industrial system. Therefore, we can use MATLAB's powerful data processing capabilities, through preparation gray GM (1.1) forecasting model of wheat production in Shandong Province, to predict the future development of wheat in Shandong Province. Furthermore, MATLAB algorithm reuse rate is very high and improved the efficiency of computing processing.

II. GRAY GM(1.1) FORECASTING MODEL

Gray system is differential equation built on a discrete sequence. GM(1.1) is a model of a first-order differential equations. By the generated mechanism of GM(1.1) albino equation, derived its time response sequence as Eq.1, Eq.2 is the reduction value formula.

$$\hat{x}^{(1)}(k) = \left(x^0(1) - \frac{b}{a}\right)e^{-a(k-1)} + \frac{b}{a} \quad (1)$$

$$\hat{x}^{(0)}(k+1) = (1 - e^a) \left(x^0(1) - \frac{b}{a}\right)e^{-ak} \quad (2)$$

Where, $-a$ is development factor, b is gray action. $-a$ reflects the development momentum of $x^{(1)}(1)$ and $x^{(1)}(0)$. b is exhumed from the background value data, which reflects the data changes, the exact meaning is ash.

The next is model building processing. The original data is as shown in table 1.

Step 1: Make the original sequence $X^{(0)}(0)$ for an accumulative sequence generated 1-AGO sequence $X^{(1)}(1)$.

Step 2: According to Eq.3, the mean sequence of the $X^{(1)}(1)$ is generated as the sequence $Z^{(1)}(1)$.

$$z^{(1)}(k) = 0.5x^{(1)}(k) + 0.5x^{(1)}(k+1) \quad (3)$$

Step 3: According to Eq.4 and Eq.5, do least squares estimation to parameters listed $\hat{a} = \begin{bmatrix} a \\ b \end{bmatrix}$.

$$a = \frac{\frac{1}{n-1} \sum_{k=2}^n x^{(0)}(k) \sum_{k=2}^n z^{(1)}(k) - \sum_{k=2}^n x^{(0)}(k) z^{(1)}(k)}{\sum_{k=2}^n \left[\left(\frac{z^{(1)}(k)}{n-1} \right)^2 - \frac{1}{(n-1) \left(\sum_{k=2}^n \left[\frac{z^{(1)}(k)}{n-1} \right]^2 \right)} \right]} \quad (4)$$

$$b = \frac{1}{n-1} \left[\sum_{k=2}^n x^{(0)}(k) + a \sum_{k=2}^n z^{(1)}(k) \right] \quad (5)$$

Step 4: Determine the model expression (as shown in Eq.6) and the time response type (as shown in Eq.7).

$$\frac{dx^{(1)}}{dt} - ax^{(1)} = b \quad (6)$$

$$\hat{x}^{(0)}(k) = (1 - e^a) \left(x^0(1) - \frac{b}{a}\right)e^{-a(k-1)} \quad (7)$$

Step 5: According to Eq.2, restore and calculate $X^{(0)}(0)$ analog values.

Step 6: Choose the relative error test method to test error, calculate the residual sum of squares and mean relative error.

Step 7: Calculate the three-step forecast data.

III. MATLAB PROGRAM OF GM(1.1) FORECASTING MODEL

The main MATLAB program is as shown in table 2.

IV. CONCLUSION

This paper has established gray GM(1.1) models of wheat acreage, production, yields of Shandong Province and the national based on the data from 1999 to 2011. The modeling analysis results are shown in table 3, the predicted results shown in table 4.

After the modeling analysis of Shandong Province and the country's wheat production data of 1999-2011 years, the statistics of wheat has been completed in 2012. Therefore, the 2012 forecast data was compared with the actual data to calculate the error, which was as shown in table 4.

Combining the average relative error in table3 and the analysis results in table5, we can see that the relative error of prediction data obtained by GM (1.1) model is smaller than actual data, within the modeling analysis expected range. Therefore, we can use GM (1.1) model to predict the future of wheat yield. As the forecast data only for the production data of wheat, and wheat production process will be affected by climate, weather, natural disasters, etc.

So in the actual analysis process can also combine the year's environment and climate prediction of wheat growing to get a more accurate predictive analysis.

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TABLE I 1999~2011 SHANDONG PROVINCE AND THE WHOLE NATION WHEAT PRODUCTION STATISTIC DATA

year	The whole nation			Shandong Province		
	Acreage	production	Yield	Acreage	production	Yield
	one thousand hectares	million tons	kg/hectare	one thousand hectares	million tons	kg/hectare
1999	28855	11388	3947	4007	2117.7	5285
2000	26653	9963.6	3738	3960	1860	4697
2001	24664	9387.3	3806	3546	1655.2	4668
2002	23908	9029	3777	3397	1547.1	4554
2003	21997	8648.8	3932	3105	1565	5040
2004	21626	9195.2	4252	3106	1584.6	5102
2005	22793	9744.5	4275	3279	1800.5	5492
2006	23613	10846.6	4593	3557	2013	5660
2007	23721	10929.8	4608	3519	1995.6	5671
2008	23617	11246.4	4762	3525	2034.2	5770
2009	24291	11511.5	4739	3545	2047.3	5775
2010	24257	11518.1	4748	3561.87	2058.6	5780
2011	24270	11740.1	4837	3593.5	2103.9	5855

TABLE II THE MAIN MATLAB PROGRAM

```

y=input('please enter the data:');
n=length(y);yy=ones(n,1);yy(1)=y(1);
for i=2:n
yy(i)=yy(i-1)+y(i);end
B=ones(n-1,2);
for i=1:(n-1)
B(i,1)=-(yy(i)+yy(i+1))/2;B(i,2)=1;end
BT=B';
for j=1:n-1

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YN(j)=y(j+1);end
YN=YN';A=inv(BT*B)*BT*YN;a=A(1);u=A(2);t=u/a;
t_test=input('please enter the forecast number:');
i=1:t_test+n;ys(i+1)=(y(1)-t).*exp(-a.*i)+t;ys(1)=y(1);
for j=n+t_test-1:2
    ys(j)=ys(j)-ys(j-1);end
x=1:n;xs=2:n+t_test;yn=ys(2:n+t_test);plot(x,y,'^r',xs,yn,'*-b');det=0;
for i=2:n
    det=det+abs(yn(i)-y(i));end
det=det/(n-1);disp([' Percentage absolute error is : ',num2str(det),'%']);
disp(['the forecast data is ',num2str(ys(n+1:n+t_test))]);

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TABLE III SHANDONG AND NATION WHEAT GM(1.1) PREDICTION MODEL PARAMETER TABLE IN 1999-2011

	Wheat Production	Development coefficient(-a)	Gray action (b)	Residual (ε)	The average relative error
Shandong Province	Yield (kg/hectare)	0.0237	4490.2082	36663.0249	2.6356%
	Acreage(one thousand hectares)	0.0008	3454.7085	594411.8515	4.7505%
	Production (million tons)	0.0261	1524.6503	182806.2172	5.4031%
Whole nation	Yield (kg/hectare)	0.0261	3591.8277	169190.0096	2.2379%
	Acreage(one thousand hectares)	-0.00181	24098.2842	18370964.789	3.7499%
	Production (million tons)	0.0260	8487.2551	3304413.0259	4.3357%

TABLE IV SHANDONG AND NATIONAL WHEAT GRAY GM(1.1) PREDICTION MODEL AND PREDICTIVE VALUE OF THE NEXT THREE YEARS

	wheat	GM(1,1) model time responsive	Reducing value calculation formula	predictive value of the next three years		
				2012	2013	2014
0	yield(kg/hectare)	$\hat{x}^{(1)}(k) = 194745.2616e^{0.0237(k-1)} - 189460.2619$	$\hat{x}^{(0)}(k+1) = 4561.2323e^{0.0237k}$	6208.0036	6356.9622	6509.4951
	Acreage (one thousand hectares)	$\hat{x}^{(1)}(k) = 4322392.6250e^{0.0008(k-1)} - 4318385.6250$	$\hat{x}^{(0)}(k+1) = 3456.5281e^{0.0008k}$	3492.5985	3495.3887	3498.1811
	production(million tons)	$\hat{x}^{(1)}(k) = 62362.7203e^{0.0261(k-1)} - 58415.7203$	$\hat{x}^{(0)}(k+1) = 1559.4548e^{0.0261k}$	2188.8204	2246.6534	2306.0144
1	yield(kg/hectare)	$\hat{x}^{(1)}(k) = 1376183142.40e^{0.0261(k-1)} - 137617.9196$	$\hat{x}^{(0)}(k+1) = 3647.0659e^{0.0261k}$	5121.0678	5256.5439	5395.6039
	Acreage (one thousand hectares)	$\hat{x}^{(1)}(k) = -13359080.6667e^{-0.0018(k-1)} + 13387935.6667$	$\hat{x}^{(0)}(k+1) = 24067.5682e^{-0.0018k}$	23503.0921	23460.2233	23417.4326
	production(million tons)	$\hat{x}^{(1)}(k) = -13359080.6667e^{-0.0018(k-1)} + 13387935.6667$	$\hat{x}^{(0)}(k+1) = 8670.4239e^{0.0260k}$	12163.5684	12484.4750	12813.8480

Note: 0—Shandong Province; 1—the whole nation.

TABLE V THE ERRORS BETWEEN ACTUAL DATA AND FORECAST DATA OF WHEAT PRODUCTION IN SHANDONG PROVINCE AND THE WHOLE NATION IN 2012

	Acreage(one thousand hectares)	Production (million tons)	Yield (kg/hectare)
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data	actual data	Forecast data	relative error	actual data	Forecast data	relative error	actual data	Forecast data	relative error
Shandong	3625.87	3492.5985	3.68%	2179.5	2188.8204	0.43%	6011	6208.0036	3.28%
Whole nation	24412	23503.0921	3.73%	12050	12163.5684	0.95%	4937	5121.0678	3.73%