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Research Article

Application Research on Predictive Analysis Model of the Relationship between China Grain Production and Consumption and Population Based on Marquardt Optimization Algorithm

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Abstract: In this study, the Marquardt method (Yuan and Sun, 1997) which can solve known nonlinear function estimation problem effectively is applied and a predictive analysis is built based on the analysis of the nonlinear relationship cases between China's grain production statistical data of population, production and consumption from 1978 to 2010 and through the example to show that the method is practical and feasible with high curve fitting degree.

Keywords: Application research, consumption and population, Marquardt optimization algorithm, predictive analysis model, relationship between china grain production

INTRODUCTION

China's cultivated area accounts only for 7% of the world's cultivated area, while China's population accounts for 22% of the world's total population. The safety of grain supply problem is related to social stability and healthy development. Discussion on a national or regional grain security, the first thing should be considered is whether the grain supply quantity satisfies people's basic needs, namely the grain supply and demand balance problem (Jing *et al*., 2004). The population, grain production and consumption are a periodic continuous growth or decline process, which is also the process of monitoring and predicting China's grain production, but also through a long-term investigation and observation. It is not an easy task to predict China's grain and population change through a long-term Investigation and observation. Taking 1978 as the starting point, trough exploring the change discipline of over the past 32 years population, grain production and consumption, to get the change characteristics and trend between China's grain production, consumption and population growth, to provide the model basis for future grain security production forecast and analysis and promote sound and rapid development of grain production in China.

MATERIALS AND METHODS

Materials: According to the data from China Statistical Yearbook (1979~2012), China grain production and consumption change from 1978 to 2010 can be got roughly. In the past 32 years in China, population has been in a process of steady growth, increasing from 962.59 million in 1978 to 1.341 billion in 2010, with the average annual growth rate of around 1.7%. At the same time, the total grain gross product has increased year by year, with the annual average growth rate of around 1.79%. An average annual growth rate of grain consumption is around 2.1% and grain production growth rate is greater than the growth rate of population and grain consumption, to ensure the safety and stability of our country grain production and supply.

Because the amount of grain supply and demand are not synchronized in time (Shi and Jin, 2013) and the imbalance between supply and demand also appeared several times reversals, for food production in China, under the constraint of people's rigid demand, the safety of grain production depends more on food supply capacity and the level of consumption ability.

This study analyzes the production, consumption and population of the past 32 years from 1978 to 2010 in China (Fig. 1) and concludes grain the changing track and according to this basis to get the

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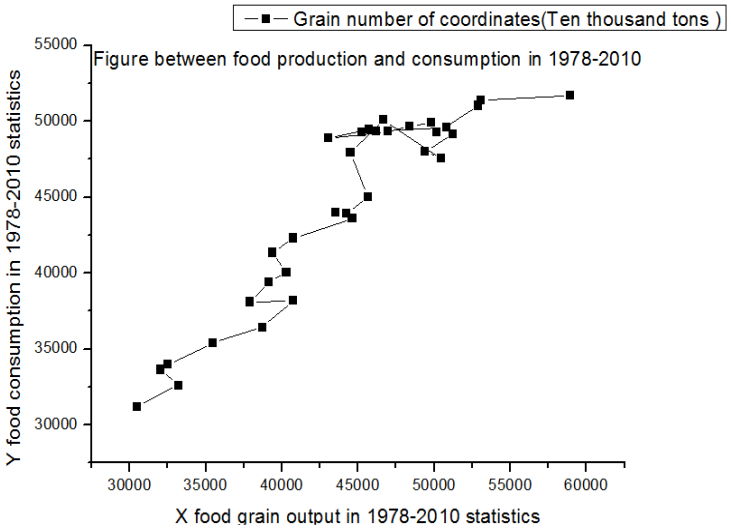

Fig. 1: The sketch map of China grain production and consumption change from 1978 to 2010

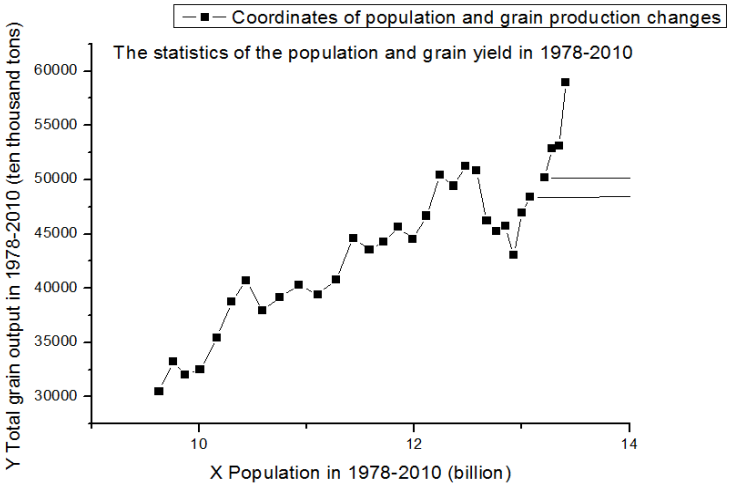

Fig. 2: The sketch map of China grain growth and consumption changes from 1978 to 2010

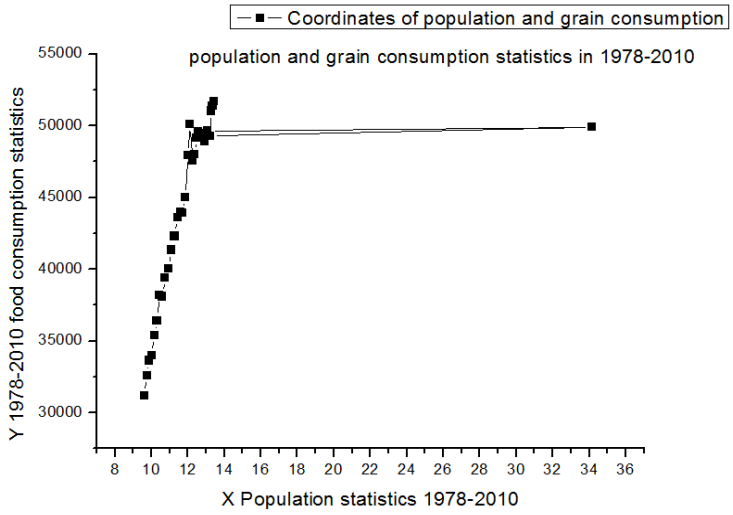

Fig. 3: The sketch map of China grain consumption and population changes from 1978 to 2010

characteristics and trend of China grain supply and need and population changes.

Based on the analysis of chart 2, although in 32 years, the average annual growth rate of China's grain output is higher than annual grain consumption rate, there are 17 years when the grain production was lower than the consumption of the years, that is to say, the structure of our country grain growth and consumption is changing with the years (Liu *et al*., 2006).

According to Fig. 2 and 3, in the past 32 years from 1978 to 2010, with the increasing of population, our country grain production was increasing but developed very unsteadily and grain gross production changed every year. Grain gross production waved steadily and regularly in short-term and the wave period range had the expanding trend (Dong, 2000) and the average waving period is 3.63 years. The average increasing interval of grain gross production in China is 2.25 years and the average decreasing interval is 1.38 years, which mean than once reduction of China grain production appears, it needs a very long time to recover to a new growth peak, but once increasing production appears, there will be a long time increasing production trend. Grain gross consumption increased rapidly with the population changing from 900 million to 1.2 billion and when the population peaks to 1.2 billion, grain consumption shows a steady growth trend and the growth rate decreases significantly, which shows that the per capita grain consumption has decreased.

Basic model (Lu *et al*., 1988): Get a set of measured data (such as N points (xi, yi) to acquire an approximately analytical solutions of independent variable x and dependent variable y). If the error is $\delta i = \varphi(x_i) - yi$, i = 1, 2, …N, then quadratic sum of error should be made the minimum, that is: $Q = \sum_{i=1}^{N} \delta^2{}_i$ is minimum, which is the principle of least square method. Supposing variable y and variables $x_1, x_2, \cdots, x_p$ satisfy the relation:

$$y = f\left(x_1, x_2, \cdots, x_p; b_1, b_2, \cdots, b_m\right)$$

In this relation, f is nonlinear function of undetermined parameters $b_1, b_2, \cdots, b_m$.

According to the N group observed value of $x_1, x_2, \cdots, x_p$ and y, in the least square sense, the algorithm of determining the parameters in the nonlinear model is given, Marquardt algorithm.

Algorithm steps: One, calculate residual error square sum:

$$X = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1p} & y_1 \\ x_{21} & x_{22} & \cdots & x_{1p} & y_2 \\ \cdots & \cdots & \cdots & \cdots & \cdots \\ x_{n1} & x_{n2} & \cdots & x_{np} & y_n \end{bmatrix}$$

First of all, the initial values $b_i^0 (i = 1, 2, \cdots, m)$ of the M parameters are given and N groups data residual error square sum Q is calculated by:

$$Q = \sum_{i=1}^{N}\left[y_i - \hat{y}_i\right] = \sum_{i=1}^{N}\left[y_i - f\left(x_{i1}, x_{i2}, \cdots, x_{ip}; b_1^0, b_2^0, \cdots, b_m^0\right)\right]^2 \quad (1)$$

Calculate coefficient a_{ij} and constant a_{iy} of equation set To make $b_i - b_i^0 = \Delta_i (i = 1, 2, \cdots, m)$, by using the least square principle $\Delta_i (i = 1, 2, \cdots, m)$ satisfies linear equation set:

$$\left.\begin{array}{c} (a_{11} + d)\Delta_1 + a_{12}\Delta_2 + \cdots + a_{1m}\Delta_m = a_{1y} \\ a_{21}\Delta_1 + (a_{22} + d)\Delta_2 + \cdots + a_{2m}\Delta_m = a_{2y} \\ \cdots\cdots\cdots \\ a_{m1}\Delta_1 + a_{m2}\Delta_2 + \cdots + (a_{mm} + d)\Delta_m = a_{my} \end{array}\right\} \quad (2)$$

In this set:

$$a_{ij} = \sum_{k=1}^{N}\frac{\partial f}{\partial b_i}\left(x_{k1}, x_{k2}, \cdots, x_{kp}; b_1^0, \cdots, b_m^0\right)\cdot\frac{\partial f}{\partial b_j}\left(x_{k1}, x_{k2}, \cdots, x_{kp}; b_1^0, \cdots, b_m^0\right);$$
$$(i, j = 1, 2, \cdots, m) \quad (3)$$

$$a_{iy} = \sum_{k=1}^{N}\frac{\partial y}{\partial x}\left(x_{k1}, x_{k2}, \cdots, x_{kp}; b_1^0, \cdots, b_m^0\right)\cdot\left(y_k - \hat{y}_k\right);$$
$$(i, j = 1, 2, \cdots, m) \quad (4)$$

d is damping factor and when $d = 0$, this is the normal Gauss-Newton iterative method.

Solve equation set and get $\Delta_i (i = 1, 2, \cdots, m)$ and then $b_i = \Delta_i + b_i^0$. When $\max_i\left|b_i - b_i^0\right| = \min_i\left|\Delta_i\right| < eps$, iteration ends. Otherwise, take $b_i^0 (i = 1, 2, \cdots, m)$ as parameter initial value and calculate step until getting the required accuracy.

Comprehensive integrated model of MOA: From the analysis of basic model above we can see that the predictive analysis of China grain production and consumption and population may be decomposed into basic model based on Marquardt optimization algorithm and this is the basis for problem solving.

If we design predictive analysis model of the relationship between china grain production and

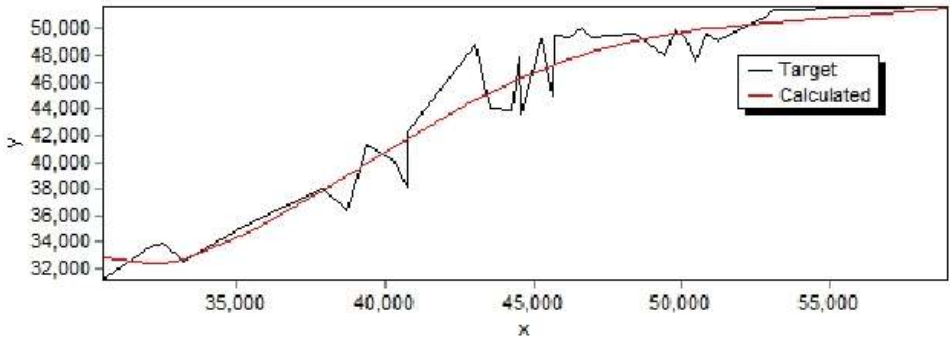

Fig. 4: The fitting compassion of grain real consumption and model-calculated consumption from 1978 to 2010

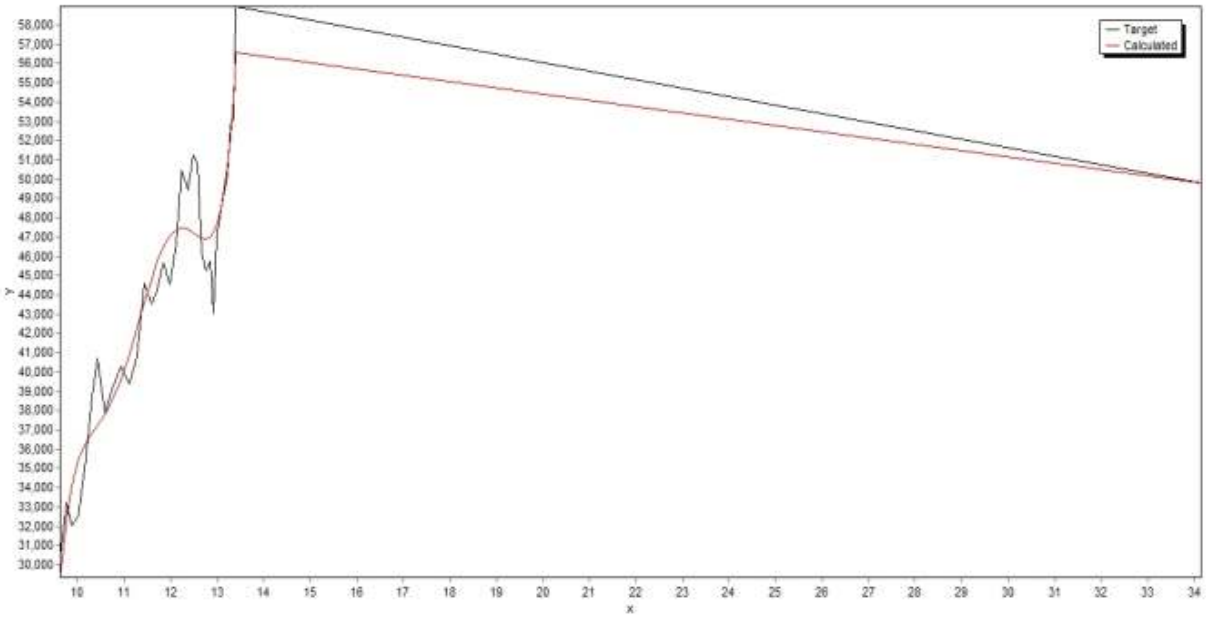

Fig. 5: The fitting compassion of grain real gross production and model-calculated production from 1978 to 2010

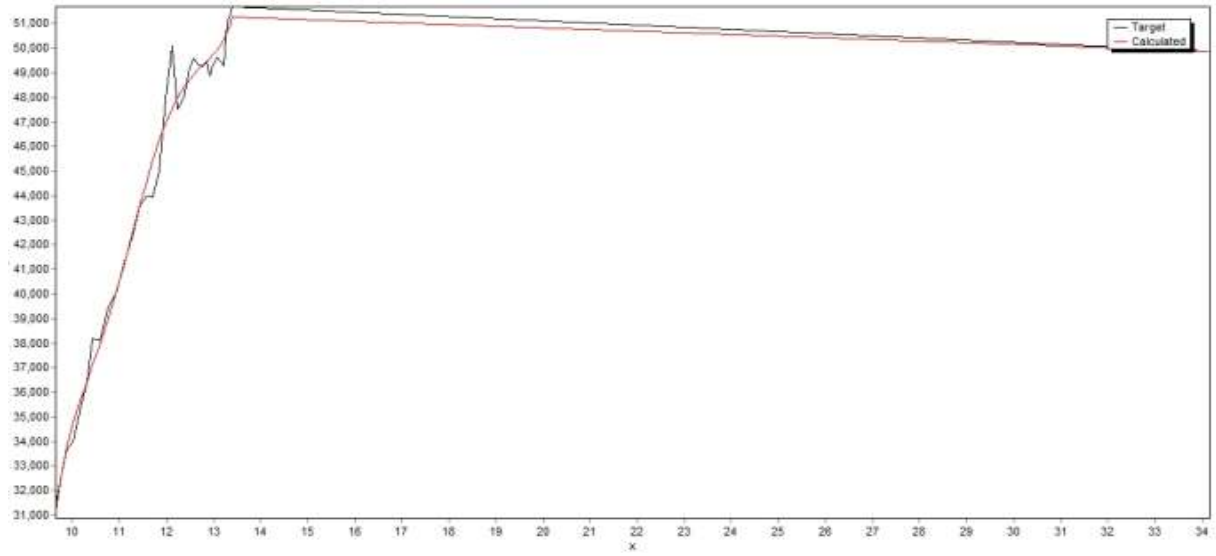

Fig. 6: The fitting compassion of grain real consumption and model-calculated consumption from 1978 to 2010

Table 1: Model of MOA

Rank	Parameters
Method	Marquardt optimization
Iterations	The maximum 1000
Output	Real-time control 20
Repeat	400 Times
Iterations	20 Iterations
Convergence	
Control	
Judgment	15 Iterations
The training	The population, the number of total grain
Sample data	Output and consumption from 1978 to 2010

consumption and population on the basis of Table 1, the next task is how to comprehensively integrate those models.

Empirical analysis: The relationship model between grain total output and consumption model (Fig. 4):

$$y = p1 + p2 \cdot x + p3 \cdot x^{\frac{3}{2}} + p4 \cdot x^{2 \cdot Ln(x)} + P5 \cdot x^{\frac{5}{2}} \quad (5)$$

The fitting degree of experiment results: Correlation Coef. (R): 0.96105073299625.

$P1$ = 2281254.40326592, $P2$ = -493.231804231696, $P3$ = 4.24333392257247, $P4$ = 0.00145537869261, $P5$= 2.567965973

The model of relationship between population and grain gross production (Fig. 5):

$$y = c1 + c2 \cdot x + c3 \cdot x^2 + c4 \cdot x^3 + c5 \cdot x^4 + c6 \cdot x^5 + c7 \cdot x^6 + c8 \cdot x^7 \quad (6)$$

The fitting degree of experiment results: Correlation Coef. (R): 0.916574347581711.

$c1$ = -196976052.043328, $c2$ = 82277813, $c3$ = 12884729.8226265, $c4$ = 824437.8, $c5$ =-1.82746, $c6$ = -2681.85, $c7$ =123.3721, $c8$ =-1.69005

The model of relationship between population and grain consumption (Fig. 6):

$$y = e1 + e2 \cdot x + e3 / x + e4 \cdot x^2 + e5 / x^2 + e6 \cdot x^3 + e7 / x^3 + e8 \cdot x^4 + e9 / x^4 + e10 \cdot x^5 \quad (7)$$

The fitting degree of experiment results: Correlation Coef. (R): 0.993052.

$e1$ = -60068275.34, $e2$ = 44005.39, $e3$ = 3479.131, $e4$ = 1127881, $e5$ = 2777312118.68, $e6$ = -111276, $e7$ = -236714, $e8$ = 4165.465, $e9$ = 59100929810.62, $e10$ = -53.6696

RESULTS AND DISCUSSION

Merits of Marquardt optimization algorithm modeling: Through the empirical study data fitting, the model shows that the fitting degree of model predicting results and actual results are all above 91%, especially the population and grain consumption reaches as high as 99.3%, which has great significance on the prediction of the relationship between China's total population, grain production and consumption and also has great significances on accurately judging China's food security situation and is good for a developing country with a large population like China.

Agent is an advanced computing, if we compare with the traditional numerical analysis method. It not only provides modeling methods, but also gives solution of the problem. In particular, agent-oriented system may deal with complex interactions between environment and the robot. Now more and more people think that the intelligence of robot is increased in these interactions.

CONCLUSION

In this study, based on the analysis of the grain gross production, population and grain consumption from 1978 to 2010 32 years, by using the Marquardt optimization algorithm, the parameters in the predicting and analysis model of China's grain production and consumption relationship were solved and the predicting results are non-linear fitted, with high fitting degree, which has practical significance to predict China's grain production and consumption and the growth of population and also can provide the basis for the decision-making departments of food production.

Based on the empirical research, the results show that, the level of food security in China continues to improve in the wave and gradually tends to be stable, but still in a mild warning condition, which needs to be concerned.

Fuzzy logical navigation and its fusion with RL based on POMDP have explained that the hybrid based on soft computing and robotic learning is a great prospect in modeling robotic system. In addition, from the basic model and its analysis model, we also see that agent indeed have brought convenience for designing robotic system. Good features of agent will make it become a new computing model in the future. The comprehensive and integrated approach based on agent is important future research directions.

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