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Forecasting Modeling and Analysis of Power Engineering in China Based on Gauss-Chebyshev Formula

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Abstract

This paper used Gauss-Chebyshev formula to construct a new class of gray prediction model- GCGM(1,1) to overcome the lack of existed gray model and made accurate forecasting of electricity consumption for power engineering. A case study using the power engineering data of China is presented to demonstrate the effectiveness of our approach.

Keywords: Gauss Chebyshev formula; GM (1, 1) model; background value; forecasting; power engineering

1. Introduction

In power engineering, electricity consumption forecasting is known as one of the most important task in energy planning and it has great significance on management decision making for power generation groups as will as power policy adjusting for government. Therefore, it is essential to predict the electricity consumption accurately.

GM(1,1) model is the most commonly approach in electricity consumption prediction. It has the advantages of few data demand, convenient calculation and used widely consequently. However, like other prediction methods, it also has some limitations. Therefore, in recent years, research on improvement and optimization for GM(1,1) model has attracted many scholars' attention.

Literature [1] uses the conventional GM(1,1) model to forecast data. But the prediction error is relatively big. Literature [2] uses Lagrange interpolation formula to reconstruct the background value. Literature [3] uses the Newton-Cores formula to reconstruct the background value, constructs (n-1)th Newton interpolation polynomial $N(t)$ of $x^{(1)}(t)$ to calculate its value in the interval $[k, k+1]$ by the Cores formula, which is the improved background value.

Research in recent years shows that reconstruction of background value with interpolation algorithm has better performance than former trapezoid method. However, all the previous researches use certain single interpolations, such as Lagrange interpolation (ref.[2]), Newton interpolation (ref.[3]), etc. These methods can improve prediction accuracy indeed, but in order to place undue emphasis on accuracy, these methods also add nodes, which lead a vibration---Runge phenomenon that causes decrease in model applicability or even make the model cannot be used.

Based on literature mentioned above, this paper proposes a method to improve the background value by Causs-Chebyshev formula. It overcomes the problems in single interpolation methods, avoids distortion and improves the theory depth of the model. It has the advantage of high accuracy, and can solve non-equidistant nodes problem. This approach can reduce the multiply operation to (n-1) times,

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which is more simple and direct to the benefit of popularizing the forecasting method in power engineering.

2. Modeling idea of conventional GM (1, 1) model

First, we introduce the modeling mechanism of traditional GM (1, 1) model.

Let $X^{(0)}=\{x^{(0)}(1),x^{(0)}(2),\cdots,x^{(0)}(n)\}$ be the original series. Make one-accumulation:

$$X^{(1)}=\{x^{(1)}(1),x^{(1)}(2),\cdots,x^{(1)}(n)\}$$

where $X^{(1)}(k)=\sum_{i=1}^{k}x^{(0)}(i)$ $(k=1,2,\cdots,n)$, $X^{(1)}(k)$ is the one-accumulation series of $X^{(0)}(k)$, denoted as $1-AGO$.

$x^{(1)}$ satisfies the following grey differential equation

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

where a,b are parameters. a is developing coefficient, and b is grey input.

In order to estimate a,b, discretely process (1), we have:

$$\Delta\left(x^{(1)}(k+1)+aX^{(1)}(k+1)\right)=b \quad k=1,2,\cdots,n-1 \tag{2}$$

where $\Delta\left(x^{(1)}(k+1)\right)$ is inverse accumulated generated on $(k+1)th$ and

$$\Delta\left(x^{(1)}(k+1)\right)=x^{(1)}(k+1)-x^{(1)}\left(k\right)=x^{(0)}\left(k+1\right) \tag{3}$$

In grey prediction, $x^{(1)}(k+1)$ in (2) is the background value of $dx^{(1)}/dt$ on $(k+1)th$, generally,

$$z^{(1)}(k+1)=\frac{1}{2}[x^{(1)}(k)+x^{(1)}(k+1)],(k=1,2,\cdots,n-1) \tag{4}$$

Induce (3), (4) into the following equations and get:

$$\begin{cases} z^{(1)}(2)=a\left[-\frac{1}{2}\left(x^{(1)}(1)+x^{(1)}(2)\right)\right]+b \\ z^{(1)}(3)=a\left[-\frac{1}{2}\left(x^{(1)}(2)+x^{(1)}(3)\right)\right]+b \\ \vdots \\ z^{(1)}(n)=a\left[-\frac{1}{2}\left(x^{(1)}(n-1)+x^{(1)}(n)\right)\right]+b \end{cases} \tag{5}$$

$$B=\begin{bmatrix}-z^{(1)}(2) & 1\\ -z^{(1)}(3) & 1\\ \vdots & \vdots\\ -z^{(1)}(n) & 1\end{bmatrix}, Y_n=[x^{(0)}(2),x^{(0)}(3),\cdots,x^{(0)}(n)]^T \quad ,\boldsymbol{\alpha}=(a,b)^T \quad ,$$

Then (5) can be simplified as the linear model $Y=B\boldsymbol{\alpha}$. Using least square estimation approach, we have

$$\boldsymbol{\alpha}=\left(B^TB\right)^{-1}B^TY \tag{6}$$

Induce (6) into (1), we obtain the discrete solution:

$$\hat{x}^{(1)}(k+1)=(x^{(0)}(1)-\frac{b}{a})\cdot e^{-ak}+\frac{b}{a} \tag{7}$$

Then, we get the prediction series:

$$\hat{x}^{(0)}(k+1)=x^{(1)}(k+1)-x^{(1)}(k)=(1-e^{a})(x^{(0)}(1)-\frac{b}{a})\cdot e^{-ak} \tag{8}$$

and $k=1,2,\cdots,n$.

From (4), we know the exploit trapezoid area is

$$S(k\cdot x^{(1)}(k)\cdot x^{(1)}(k+1)\cdot(k+1))$$