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Analysis of Fire Rescue Problems Based on Prediction and Fitting Algorithm

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Abstract: This paper studies the problem of fire rescue. According to the population, area, police situation and other data in different regions of the area, the number of police calls is predicted. Firstly, according to the data from 2016 to 2019, draw the image of the number of alarms changing with months; Then, polynomial model fitting and local weighted regression are used to predict the data in 2020 and compared with the real value; The square loss function is used to evaluate the accuracy of the model, and then the sensitivity analysis is carried out to evaluate the stability of the model; Finally, the model is used to predict the number of fire rescue calls in each month of 2021.

1. Introduction

With the development of urbanization, various potential safety problems are becoming increasingly prominent, so the fire rescue work is becoming more and more important. How to summarize and predict the diversification and complexity trend of fire rescue tasks and give reasonable and effective countermeasures according to the existing data is an urgent problem to be solved.

Based on the existing alarm records, this paper forecasts the monthly alarm situation in the next year. After sorting and summarizing the monthly alarm times from 2016 to 2019, use different models to fit the existing data, compare the actual monthly alarm times in 2020 with the prediction results of different models, obtain the reliability, analyze the stability and accuracy of the model, and select the most appropriate model to complete the prediction of fire rescue alarm times in each month of 2021.

2. Model Establishment and Solution

Firstly, according to the data from 2016 to 2019, take the year and month as the independent variable and the number of police calls as the dependent variable, draw a three-dimensional scatter diagram and observe its approximate change. It can be found that the number of police calls in May

2016 was the highest, 275, much higher than that in other months.

Then predict the future data according to the existing data. In order to find the best prediction results, we use multiple functions to predict the future data. After using polynomial model fitting, locally weighted regression model, cubic spline interpolation and biharmonic spline interpolation model, it is found that biharmonic spline interpolation has the highest fitting degree, so this method is used for prediction. The following is the comparison between the predicted results and real values of different models:

Firstly, biharmonic spline interpolation is used for fitting. The derivative of Biharmonic technology in two-dimensional or multi-dimensional space is similar to that in one-dimensional space. In the m-dimensional space of this paper, it is necessary to solve the problem by using the surface of N data points.

$$\triangle^4\ \omega(x) = \sum_{j=1}^{N} \alpha_j \delta(\mathrm{x} - x_j)$$

$$\omega(x_j) = \omega_j$$

$$\triangle^4\ is\ a\ biharmonic\ operator, and\ X\ is\ a\ position\ in\ m\ dimensional\ space.$$

In this question, M = 2, n = 48. The general explanation is as follows:

$$\omega(x) = \sum_{j=1}^{N} \alpha_j \Phi_m(\mathrm{x} - x_j)$$

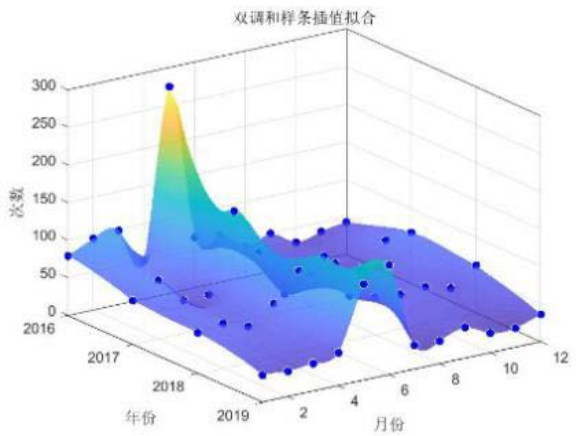
Solving the linear system, we can get α_j

$$w_i = \sum_{j=1}^{N} \alpha_j \Phi_m(\mathrm{x} - x_j)$$

The following table gives biharmonic Green's functions in one and two-dimensional space.

Table 1: Biharmonic Green's functions in one and two dimensional space

Dimension	$Green'sfunction$ $\phi_m(x)$	$GradientofGreen'sfunction$ $\triangle\ \phi_m(x)$
1	$\lvert x\rvert^3$	x|x|
2	$\lvert x\rvert^2(\ln\lvert x\rvert - 1)$	2x($\ln x - 1$)



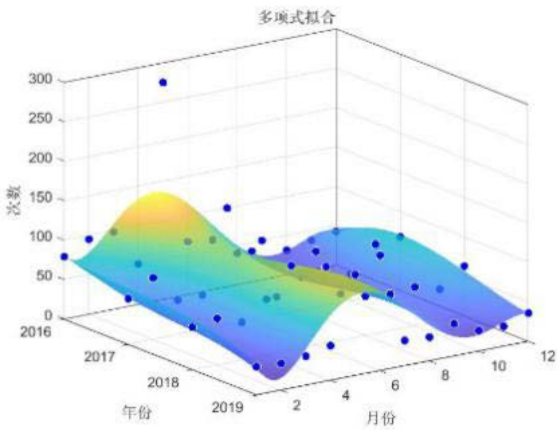


Figure 1: Fitting results of Biharmonic difference model *Figure 2: Model constructed by polynomial fitting*

Figure 1 shows the data from 2016 to 2019 fitted by biharmonic difference model. Due to the interpolation method, the accuracy of the model in predicting the data from 2016 to 2019 has reached 100%. In addition, the model predicts the number of police calls per month in 2020 as follows:

23, 28, 36, 48, 57, 57, 47, 35, 28, 24, 23, 26

The goodness of fit is 0.8271, which fits well with the actual situation. Therefore, this model is considered to be used as the prediction model of fire rescue alarm times [1].

Figure 2 is a model constructed using polynomial fitting. It can be seen from the figure that the model is evenly distributed and can not describe more prominent points, such as the number of police calls in May 2016. The prediction of the number of police calls per month in 2020 by using the model is as follows:

-22, -51, -23, 13, 30, 23, -1, -29, -44, -36, -3, 40

The goodness of fit was 0.6449. It can be seen from the figure that there is a great deviation between the prediction of the model and the actual value, and even a negative number. Therefore, we abandoned the model.

The schematic diagram of bicube interpolation is shown in Figure 3. The interpolated points in the algorithm are obtained based on 16 adjacent points. Compared with bilinear interpolation and nearest neighbor interpolation, the image obtained is smoother. The following is the basic formula and principle of bicubic interpolation. The interpolation position of the point to be determined is determined through the reading of P (x, y) image data points, so as to realize the deblurring and high-quality amplification of the image.

$$\mathrm{M(p,q)=F(t)P(x,y)F(s)=[f(1+t)f(t)f(1-t)f(2-t)]}\times\begin{bmatrix}P_{11} & P_{12} & P_{13} & P_{14}\\ P_{21} & P_{22} & P_{23} & P_{24}\\ P_{31} & P_{32} & P_{33} & P_{34}\\ P_{41} & P_{42} & P_{43} & P_{44}\end{bmatrix}\begin{bmatrix}f(1+s)\\ f(s)\\ f(1-s)\\ f(2-s)\end{bmatrix}$$

$$f(x)=\frac{\sin \pi x}{\pi x}\begin{cases} 1-2|x|^2+|x|^3, 0 \le |x| < 1 \\ 4-8|x|+5|x|^2+|x|^3, 1 \le |x| < 2 \\ 0, 2 \le |x| \end{cases}$$

In the formula $s = p - [p]$; $t = q - [q]$; $M(p, q)$ is the point to be interpolated.

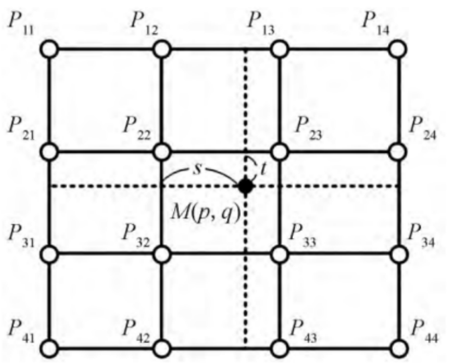


Figure 3: bicubic interpolation

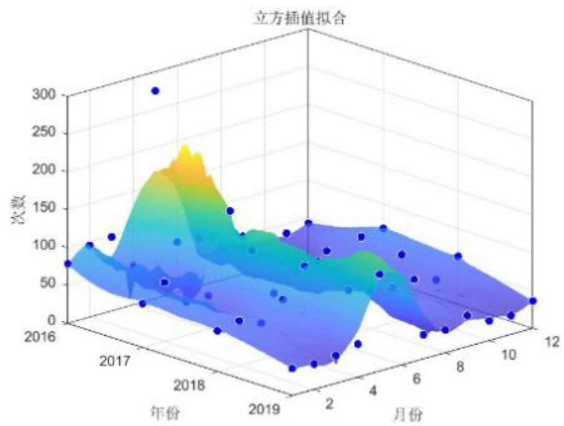


Figure 4: Results of cubic difference fitting model

Figure 4 is a comparison of the prediction of the number of police calls per month from 2016 to 2019 and the real value made by using the cubic difference fitting model [2] [3], it can be seen that compared with the polynomial fitting model, the model can reflect the data with large fluctuation. Using the model, the prediction results of the number of police calls per month in 2020 are as follows:

24, 29, 45, 71, 111, 110, 68, 33, 28, 26, 30, 5

The goodness of fit was 0.7963. It can be seen that the prediction result of this model is more reliable than that of polynomial fitting model, but the error is still large. Therefore, biharmonic spline interpolation is used as the prediction model.

The prediction results of the number of police calls from January to December 2020 using this model are as follows:

23, 28, 36, 48, 57, 57, 47, 35, 28, 24, 23, 26

Next, the accuracy and stability of the prediction results are analyzed. Using the square loss function after eliminating dimension.

$$l(Y, F(X)) = \frac{1}{2m}\sum_{i=1}^{m}\left(\frac{f(x_i)-y_i}{y_i}\right)^2$$

The calculated value is 0.0698, which is small, in good agreement with the actual situation and has high accuracy.

3. Conclusion

In conclusion, the biharmonic spline interpolation model has good accuracy and stability, and has high reliability for the prediction results of fire rescue alarm times in each month of 2021. In addition, the number of police calls in 2021 predicted based on this algorithm is shown in Table 2.

Table 2: Forecast results of number of police calls in 2021

Month	Predicted value (Times)
2021.01	11
2021.02	15
2021.03	20
2021.04	24
2021.05	26
2021.06	27
2021.07	25
2021.08	23
2021.09	21
2021.10	20
2021.11	20
2021.12	21

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