Journal of Electronics and Information Science (2021) 6: 59-63
Clausius Scientific Press, Canada

DOI: 10.23977/jeis.2021.060209
ISSN 2371-9524

Research on fire rescue using grey prediction model

Qing Yu

School of mathematics and physics, Chengdu University of technology, Chengdu, Sichuan, 610051

Keywords: 0-1Planning model, Grey prediction model, Fire rescue planning

Abstract: With the rapid development of China's economy, the tasks undertaken by fire rescue teams also show a trend of diversification and complexity.In order to strengthen the construction of the national fire rescue team and improve the accuracy and safety of the police task, this paper forecasts the number of people on duty on holidays and daily time every year by establishing a planning model.Then, through the quantitative collection of the number of police calls per month from 2016 to 2019, the number of police calls per month in 2020 is verified, the number of police calls per month in 2021 is predicted, and compared with the actual data to evaluate the accuracy and stability of the model.

1. Establishment and solution of model

1.1 0-1 programming model

First, read the data containing date and time, generate the distributed data set with data frame, use the timestamp method in pandas package to convert the input time data in string format into data in time format, and then call the apply method to extract each time characteristic attribute in the data according to year, month, day, hour, minute and second, and then such a list [- 1,8,16,24] is used as a time slice. Set the label, label the three time periods allocated in the form of open interval with 'I','II','III', and output them to a TXT file for subsequent analysis and sampling.Extract the dates around 1st February, 1st May , 1stAugust and 1st November of each year (about 20 days in total) as the samples for estimation and prediction.Count the number of police calls in three time periods, including the first day of each month, the first ten days and the next ten days:

According to the above analysis characteristics, the preliminary result of multiplying the ratio of each period by 30 can be obtained:

Table 1: Number of police calls in the first and last ten days of each month

Time	Period I	Period II	Period III
1st February	22	101	86
1st May	37	299	128
1stAugust	38	56	40
1st November	30	72	34

0-1plan:

On a certain day, there are A1, A2, A3,... A30 people to complete the work in B1, B2 and B3

Respectively,

$$x_{i,j} = \begin{cases} 1, Assignment\ A\ \ work\ in\ time\ period\ B \\ 0, Assignment\ A\ does\ not\ work\ in\ time\ period\ B \end{cases}$$

Since each person only works in one time period, and at least 5 people are allocated in each time period, the characteristics of the three periods analyzed according to the month are as follows:

$$(x_{11} + x_{21} + \ldots + x_{301}) < (x_{13} + x_{23} + \ldots + x_{303}) < (x_{12} + x_{22} + \ldots + x_{302}) \quad (1)$$

Program and output with LINGO software, count the number of people in three time periods, and then make a slight adjustment according to the characteristics associated with each time period and month, and the results are as follows:

Table 2: Number of police calls in the first and last ten days of each month

Time	Period I	Period II	Period III
1st February	5	13	12
1st May	5	18	7
1stAugust	8	13	9
1st November	7	16	7

Result analysis: because the crowd activities at noon are more frequent and intensive than those in the morning and evening, the number of events at noon should be more than that in the morning and evening. Similarly, the probability of events at night is slightly more than that in the morning, so the arrangement of the person on duty is more reasonable.

1.2 Establishment and solution of grey prediction model

In months, the number of alarms from January to December 2016 to 2019 is written into the data column in turn

$$x^{(0)} = \{x^{(0)}(1), x^{(0)}(2), x^{(0)}(3), x^{(0)}(4)\} \quad (2)$$

After accumulating to generate a new sequence, you can get

$$x^{(1)}(i) = \left\{ \sum_{j=1}^{i} x^{(0)}(j) \mid i = 1, 2, \ldots, N \right\} \quad (3)$$

The discrete form and prediction formula are as follows:

$$\begin{aligned} \Delta^{(1)}(x^{(1)}(k+1)) + a(x(k+1)) &= u \\ \hat{x}^{(1)}(k+1) &= \left[x^{(1)}(1) - \frac{\hat{u}}{\hat{a}} \right] e^{-\hat{a}k} + \frac{\hat{u}}{\hat{a}} \end{aligned} \quad (4)$$

After finishing, the following formula is obtained

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

Let $y=(x^{(0)}(2),x^{(0)}(3),L,x^{(0)}(N))^T.B=\begin{bmatrix}-\frac{1}{2}[x^{(1)}(2)+x^{(1)}(1)] & 1\\ -\frac{1}{2}[x^{(1)}(3)+x^{(1)}(2)] & 1\\ \cdots & \cdots\\ -\frac{1}{2}[x^{(1)}(N)+x^{(1)}(N-1)] & 1\end{bmatrix},U=\begin{bmatrix}a\\u\end{bmatrix},$

Then $y=BU$, and its least squares estimation is:

$$\hat{U}=\begin{bmatrix}\hat{a}\\\hat{u}\end{bmatrix}=(B^TB)^{-1}B^Ty \tag{6}$$

It has been calculated $\hat{x}^{(1)}$, and$\hat{x}^{(1)}$ is converted into $\hat{x}^{(0)}$:

$$x^{(0)}=\{x^{(0)}(1),x^{(0)}(2),x^{(0)}(3),x^{(0)}(4)\} \tag{7}$$

1.3 Forecast of alarm frequency

(1) Prediction graph

MATLAB and SPSS software are used for data analysis to systematically predict and calculate the estimated number of police calls in each month of 2020 and 2021 (as shown in the figure,which the red line represents estimate value,and the blue line represents the true value).

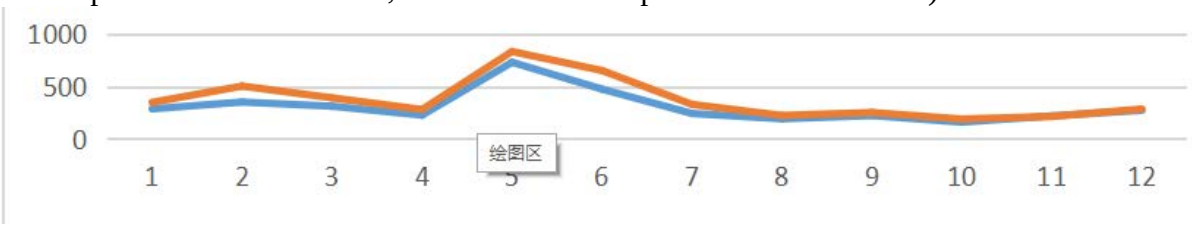

Figure 1: Distribution of 2020 alarm times based on grey prediction accumulation sequence

Analysis: in terms of the number of alarms, since 2016, the number of alarms has generally tended to change gently, but there is a significant increase in some months. The reason may be that fires are more likely to occur in summer. Because the model is an estimate of the overall number of police calls, it can judge the occurrence of various events.Subdivided into various events, it is also necessary to consider the impact of other relevant factors.

2. Model accuracy and stability evaluation

For the prediction of the number of police calls in each month in 2020, firstly, the known relationship between each month in three years is fitted by MATLAB software to obtain the prediction value of the number of police calls in each month in 2020 and 2021.The actual number of police calls in 2020 is compared with it.The results are shown in Table 3 below:

Table 3: Comparison between predicted value and actual value in 2020

The moon	The true value	The grey prediction	relative error	Time series prediction	relative error
1	28	89.9851	2.213754	62	1.214286
2	23	174.8522	6.60227	79	2.464783
3	28	107.9441	2.855146	68	1.428571
4	46	99.4657	1.162298	42	-0.08696
5	62	167.7263	1.705263	164	1.645161
6	55	232.3326	3.224229	102	0.854545
7	25	111.4398	3.457592	52	1.08
8	29	61.2647	1.112576	38	0.310345
9	36	64.8841	0.802336	44	0.222222
10	25	54.8175	1.1927	31	0.24
11	51	45.8769	-0.10045	39	-0.23529
12	62	74.5892	0.203052	50	-0.19355

It is found that the difference between the predicted value and the actual value is relatively large, and the reason for it is found that the influence of COVID-19 in 2020 may lead to a significant reduction in the number of policemen everywhere.Therefore, we can think that the predicted value obtained under the time series method is more accurate.Taking 0.5 as the segmentation limit, it can be seen that six predicted values are relatively accurate and six are not within the range.

Therefore, the stability of the predicted value under the time series is analyzed, and the stability index psi is introduced.As shown in Table 4 below:

Table 4: Data in 2020

The moon	Actual proportion	Expected proportion	Ln(Actual proportion/ Expected proportion)	Actual proportion-Expected proportion
1	0.059574	0.080415	-0.299974196	-0.02048
2	0.048936	0.102464	-0.738997958	-0.05353
3	0.059574	0.088197	-0.392347516	-0.02862
4	0.097872	0.054475	-0.585927457	0.043398
5	0.131915	0.212711	-0.4777776364	-0.0808
6	0.1107021	0.132296	-0.122683949	-0.01527
7	0.053191	0.067445	-0.237412215	-0.01425
8	0.061702	0.049287	0.224665349	0.012415
9	0.076596	0.057069	0.294284983	0.019527
10	0.053191	0.040208	0.279844299	0.012984
11	0.108511	0.050584	0.763219665	0.057927
12	0.131915	0.064851	0.710067058	0.067064

The PSI is 0.23032726, which higher than 0.2, which indicates that the factors considered in this model are not enough, because COVID-19 is a sudden factor and is not as persistent as time.Therefore, the model is still selected to predict the number of police calls in 2021.In case of emergencies, we need to comprehensively consider various factors and introduce multi-dimensional random variables.To improve the prediction accuracy of the model.

Therefore, the model is used to predict the number of police calls in 2021, as shown in Table 1.

References

[1] Weixin_34026276, feature engineering of machine learning 70% of the timehttps://blog.csdn.net/weixin_34026276/article/details/93458278, 2021.5.13.
[2] Si Shoukui, sun Zhaoliang, mathematical modeling algorithm and application, Beijing: National Defense Industry Press, 2017.
[3] Abc012377, SPSS Pearson correlation analysis example operation steps, https://wenku.baidu.com/view/d0b836b5bd64783e09122bb3.html, 2021.5.3.
[4] Fanjufei' s blog gives a set of data and predicts the trend of data change in the future through the grey prediction model,https://blog.csdn.net/fanjufei123456/article/details/84780018, 2021.5.3.