Research on the EGTM of Certain type of Turbine Engine Based on Exponential Smoothing Preditiction Method

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Abstract

Smoothing Preditiction also known as Trend Extrapolation,is a simple and comprehensive time prediction technique.It is a method to study the evolution of the predicted objects and their future trends. It predicts the future according to the present evolution characteristics, and does not consider the randomness. If the further evolution of the law can be maintained, the smoothing method is a simple and effective method of prediction, and the application effect is very good.

Keywords

EGTM , Exponential Smoothing,Turbine Engine,prediction.

1. Introduction

Flight safety is the eternal theme of civil aviation, and aero engine is called the core of aircraft. It provides the necessary power for the normal operation of the aircraft. The safety and reliability of the engine operation and the prevention of the failure are the key to ensure the safety of the flight[1]. Predicting the trend of engine parameters is conducive to promoting the safety monitoring of aeroengine, assist the engineers to determine the maintenance of aircraft engine more scientifically, decide the engine Prognostics and health management, change the present situation of passive maintenance and take corresponding preventive measures[2].

2. Organizations of the Text

2.1 Theoretical basis

In this section, we briefly describe some basic concepts and basic operational laws related to exponential smoothing method. The smooth prediction is divided into the moving smoothing method and the exponential smoothing method, and the latter is the improvement and development of the former. Therefore, this paper uses exponential smoothing method to predict[3]. The exponential smoothing prediction method has an index prediction method, the two index prediction method and the three index prediction method[4]. The first index prediction method is applicable to data that does not include a continuous trend of growth or decline. If there is linear trend in data, we should use two exponential smoothing prediction models. For aero-engine data containing curve trend, three times exponential prediction model is generally adopted[5].

$$y_{t+T} = a_t + b_t * T + c_t * T^2 \tag{1}$$

Where the a_t, b_t, c_t,in order to determine the values we can use the formula below:

$$a_t = 3S_t^{(1)} - 3S_t^{(2)} + S_t^{(3)} \tag{2}$$

$$b_t = \frac{\alpha}{2(1-\alpha)^2}[(6-5\alpha)S_t^{(1)} - 2(5-4\alpha)S_t^{(2)} + (4-3\alpha)S_t^{(3)}] \quad (3)$$

$$c_t = \frac{\alpha^2}{2(1-\alpha)^2}(S_t^{(1)} - 2S_t^{(2)} + S_t^{(3)}) \quad (4)$$

Where $S_t^{(1)}$ is One time exponential smoothing value;

$S_t^{(2)}$ is the two exponential smoothing value;

$S_t^{(3)}$ is three exponential smoothing value,and it depends on

$S_t^{(3)} = a S_t^{(2)} + (1-\alpha) S_{t-1}^{(3)}$;

α is the weight coefficient and the usual value from 0.01 to 0.30,in this paper in order to simplify the calculation process we assume α =0.15.

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2.2 Data acquisition

In this paper, I use the data of 340 EGTM in the take-off stage of an airline company's CFM-5B engine to predicte, see Fig. 1.

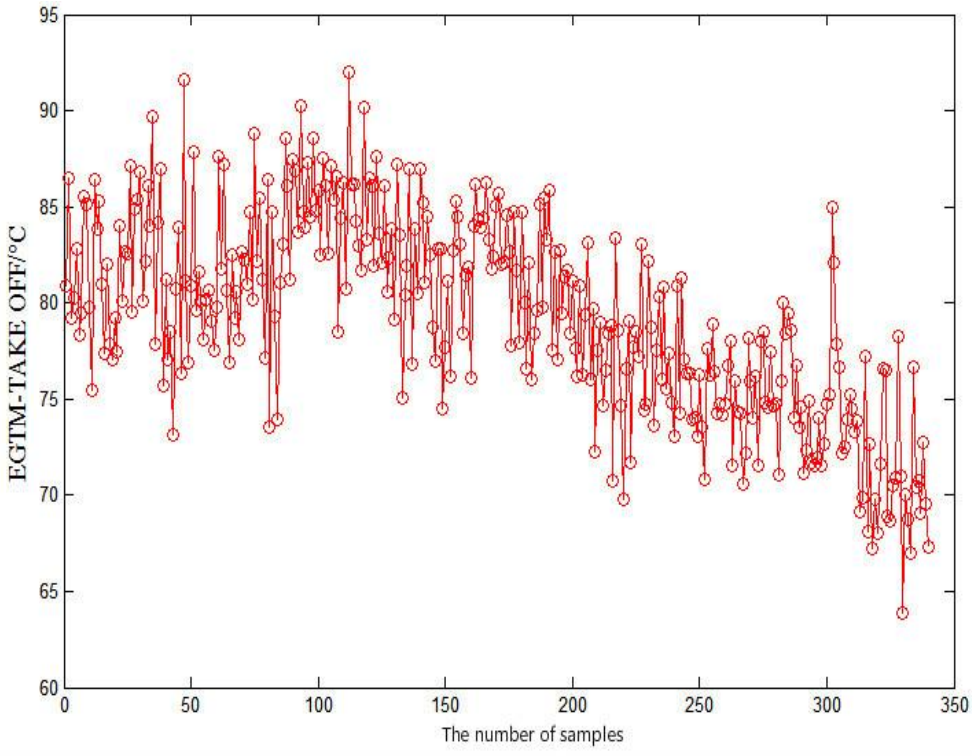

Fig. 1 Raw EGTM data

2.3 Data handling

Because some abnormal situations will inevitably appear during the flight of aircraft. There are some data that do not conform to the normal conditions, which will have an impact on the final results, and will also affect the accuracy of prediction[6]. It is therefore necessary to preprocess the data. In this paper, MATLAB is used to identify abnormal data. It is found that there are anomalies in 13, 39, 50, 79, 86, 111, 129, 150, 217, 222, 300, 305, 329 and 329.See Fig. 2

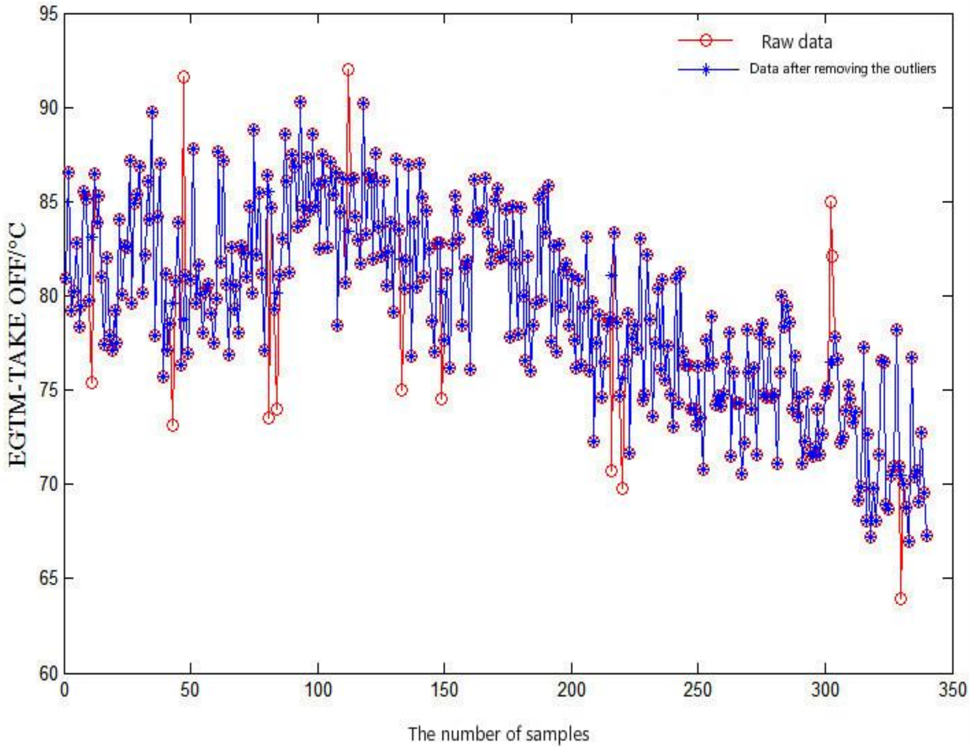

Fig. 2 Data after removing the outliers

At the same time, MATLAB is used to deal with the problem that the data fluctuation is too large during the actual analysis and prediction of aeroengine gas path performance parameters.See Fig. 3.

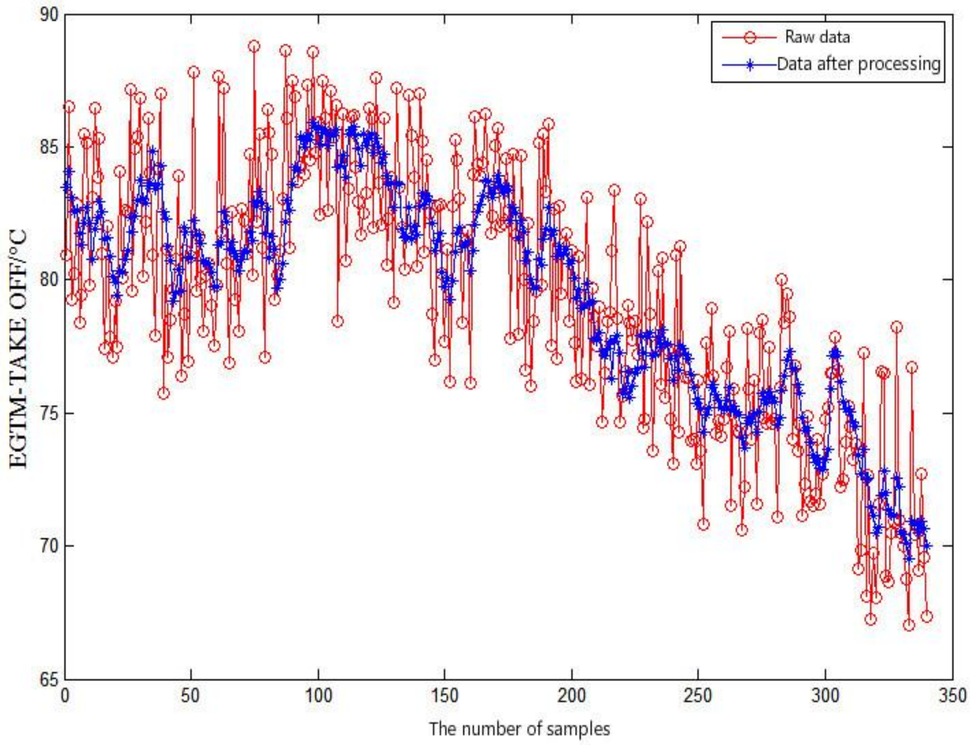

Fig. 3 Data handling by MATLAB

2.4 EGTM data prediction

Through the Fig. 3 320 data, the following 20 data are predicted by the exponential smoothing method.See Fig. 4.

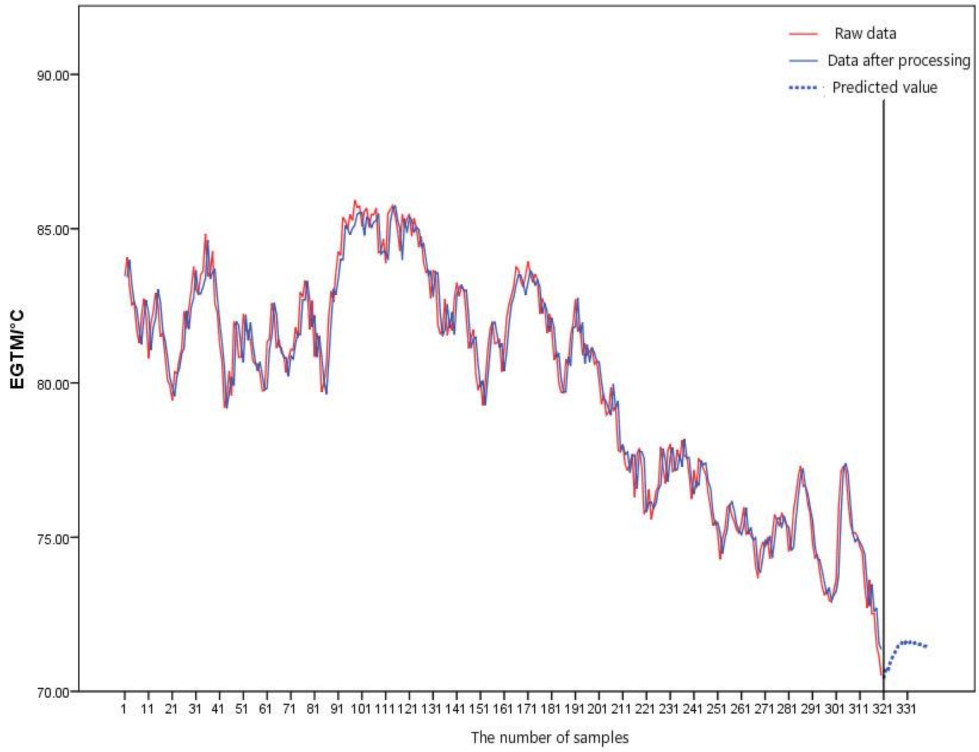

Fig. 4 EGTM data prediction results

2.5 Error analysis

In this part we calculate the absolute error,relative error.See Table 1. We find that the error is very small. The prediction results are close to the true value.

Table 1 Error analysis results

NO.	Raw data	Predictive value	Absolute error	Relative error	NO.	Raw data	Predictive value	Absolute error	Relative error
1	70.73	70.58	0.15	0.0021	11	70.457	71.78	1.323	0.0187
2	71.899	70.84	1.059	0.0147	12	70.115	71.59	1.475	0.0210
3	72.819	70.7	2.119	0.0291	13	69.494	71.72	2.226	0.0320
4	72.034	71.16	0.874	0.0121	14	70.935	71.68	0.745	0.0105
5	71.358	71.2	0.158	0.0022	15	70.837	71.61	0.773	0.0109
6	71.188	71.28	0.092	0.0013	16	70.821	71.62	0.799	0.0113
7	71.139	71.57	0.431	0.0061	17	70.476	71.57	1.094	0.0155
8	72.555	71.6	0.955	0.0131	18	70.926	71.52	0.594	0.0084
9	72.24	71.66	0.58	0.0080	19	70.656	71.51	0.854	0.0121
10	70.572	71.61	1.038	0.0147	20	69.99	71.46	1.47	0.0210

3. Conclusion

The prediction accuracy is high by this method. The influence of the external situation is relatively small. It is adaptable, that is to say, the prediction model can automatically identify the changes in the data pattern and adjust it. In practice, only one model parameter is selected, and it can be predicted easily and easily[7].

Acknowledgements

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