Analysis of QAR Data Influencing Flight Quality in Approach

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Abstract

In the process of approach phase, prone to human error caused by the occurrence of unstable approach. In order to facilitate the study of the flight quality of the approach phase, this paper analyzes the QAR data of the approach phase. In this paper, the radial basis function neural network fitting method is used to preprocess QAR data. Then the QAR data are used to analyze the influence of meteorological environment parameters, manipulations and attitude parameters on the flight quality of the approach. Through this study, we further explore the factors that affect the flight quality of the approach, which is of practical significance to the safety of flight.

Keywords

Approach phase; Flight quality; QAR; Radial basis function.

1. Introduction

The quick access recorder is an airborne device for monitoring and recording flight data, and can collect hundreds of data at the same time, covering most of the aircraft flight quality parameters. QAR is the primary source of data for routine analysis and research on flight quality monitoring, flight performance and troubleshooting. Approach time is short, the environment is complex, the task is heavy, is the flight accident multiple phase. Flight crew should have excellent psychological quality and skilled driving skills, strict implementation of the standard operating procedures to enhance the stability of the approach and the ability to break the decision to ensure flight safety. Therefore, this paper analyzes the QAR data from the factors influencing the flight quality of the approach.

2. Processing of QAR Data

As the QAR data sampling frequency is low, the data noise is more and the recording error occurs, the data may be missing and abnormal value, which requires data quality analysis and processing. In order to solve the above problems, the method of curve fitting can be used to determine and eliminate invalid data, eliminate system errors and reduce random noise in the signals [1]. Reconstructing the actual curve of key parameters in flight phase, so that the precision of parameters can meet the requirement.

The traditional method of curve fitting is to approximate the discrete data by analytic expressions, such as least square fitting. With the development of nonlinear theory such as artificial neural network and its application in the field of curve fitting, the nonlinear theory is applied to curve fitting, and the traditional method has been developed and improved [2]. This paper presents the application of curve fitting in QAR data. According to the requirements of the fitting effect and accuracy data, the radial basis function neural network can be used to fit the QAR data. The nonlinear function of radial basis function neural network can approach any regularity, can handle the system to parse, has good convergence speed and generalization ability of learning, so the use of radial basis function neural network is more suitable for the fitting of QAR data.

QAR data fitting is mainly aimed at some continuous variation of flight parameters. Considering the possible data missing, data anomalies and recording noise, the data fitting is carried out. The vertical acceleration is taken as an example to illustrate the fitting process.

RBF neural network is a three-tier network structure, as shown in Figure 1 below. The input layer only transmits the input signals to the hidden layer, and the hidden layer nodes are composed of Gauss functions, while the output nodes are simple linear functions. The base functions in the hidden layer nodes will respond locally to the input signal[3]. The most commonly used basis function is the Gaussian function.

$$h_i(x) = \exp\left[-\frac{\|x-c_i\|^2}{2\sigma_i^2}\right], \quad i = 1,2,\cdots m \tag{1}$$

Among them, x is the n-dimensional input vector. c_i is the center of the i-th base function, and the vector with the same dimension as x. σ_i is the i-th perceived variable, which determines the width of the center of the base function. m is the number of sensing units. $\|x-c_i\|$ represents the distance between x and c_i. The input layer implements a non-linear mapping from x to $h_i(x)$, and the output layer implements a linear mapping of $h_i(x)$ to y_k.

$$y_k = \sum_{i=1}^{m} w_{ik} h_i(x), \quad k = 1,2,\cdots r \tag{2}$$

Among them, r is the number of output nodes, w_{ik} is the weight.

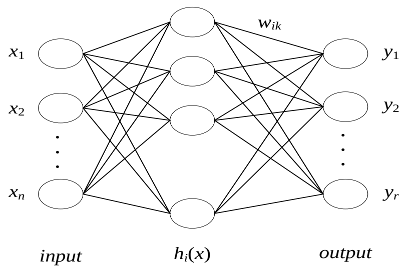

Fig. 1 RBF neural network structure

Select a set of vertical acceleration values in the near phase for RBF neural network curve fitting, and the QAR data are shown in Table 1 below.

Table 1. QAR data of vertical acceleration

Time/s	1	2	3	4	5	6	7	8	9	10
Vertical acceleration/g	0.967	0.968	0.963	0.958	0.952	0.948	0.947	0.949	0.951	0.949

Using MTLAB software[4], the trained fitting output is shown in figure 2. The error of the RBF network is very small, the curve is relatively smooth, the convergence speed is fast and the accuracy is very high. It can meet the requirements of engineering calculation and experiment.

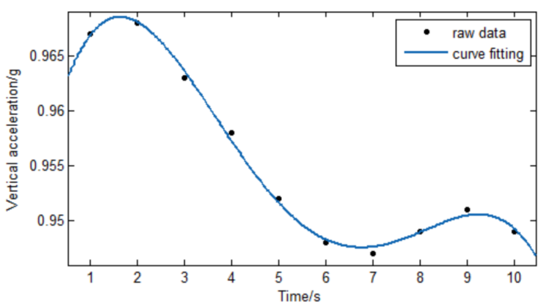

Fig.2 Fitting curve of RBF

3. Comprehensive Analysis of QAR Flight Data

There are many factors that affect the flight quality of aircraft approach phase, including meteorological environment, flight attitude, engine state, flight control and so on. Based on the flight data recorded by QAR, the effects of meteorological environment, flight control and flight attitude parameters on aircraft flight are analyzed in this paper.

3.1 Impact of Flight Meteorological Environment Parameters.

In flight, the use of favorable factors in the meteorological can guarantee flight safety, but also to achieve the purpose of saving operating costs and improve economic efficiency. Aircraft at all phase of the flight will be affected by meteorological conditions, mainly divided into visible weather phenomena and invisible weather phenomenon.Visible weather phenomena such as thunderstorms, fog, heavy rain, etc., invisible weather phenomena such as air bumps, wind shear, air ice, etc., but the main meteorological factors affecting the flight is the wind, air temperature and barometric.

The influence of wind is relatively complex, including average wind speed and instantaneous wind speed in different periods. Compared with the flight direction, it can be divided into the different situation and characteristics of the tailwind, the crosswind and the upwind[5].

The effect of air temperature on flight performance is multifaceted. As the height is different, the difference in air temperature leads to differences in air density, which affects the aerodynamic performance of the aircraft, including maximum flight speed, aircraft load and aircraft lift. The effect of barometric on aircraft flight is mainly reflected in the measurement of flight height, flight speed and so on. The following is the impact of wind on the aircraft navigation as an example, combined with QAR data analysis of the impact of meteorological environment on flight.

As the the aircraft flying in the air by the wind influence, the track line is always on the leeward side of the course line, resulting in drifting. The angle between the track and the course can be expressed by the angle between the ground speed vector and the true airspeed vector, which is called the drift angle. Figure 3 shows the speed triangle. Among them, MTK is the magnetic track angle, MH is the magnetic heading, TAS is the true airspeed, GS is the ground speed, DA is the drift angle, WS is the wind speed, WA is the wind angle, WD is wind direction.

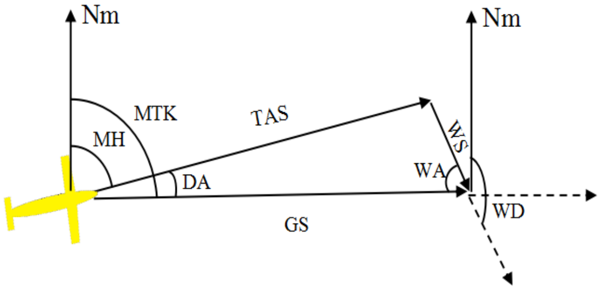

Fig. 3 Velocity triangle

It is precisely because of the reasons for the crosswind, the aircraft must make certain corrections to the current heading if it is to fly in accordance with the intended track, so that the actual flight path meets the predetermined requirements. In figure 4 and figure 5 show the wind speed and wind direction of QAR data of an airline A321 type aircraft from intercepting radio height at 2000 feet away from the airport to the main air ground switch grounding’s 251 data. It can be seen from the scatter diagram that the wind speed and wind direction are complicated in the approach phase, which is bound to have an impact on the flight. Therefore, the approach phase must be vigilant and adjust the operation according to the wind speed and the wind direction.

To sum up, the influence of wind is the factor that cannot be neglected during flight. Similarly, the influence of other meteorological environment factors on flight cannot be ignored. It is necessary to take full account of the flight quality.

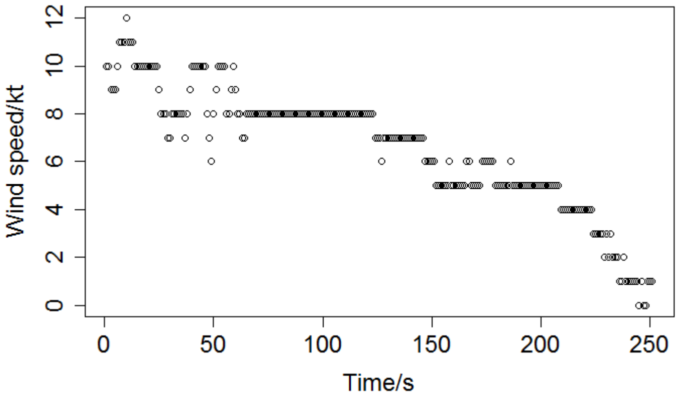

Fig. 4 Changes in wind speed

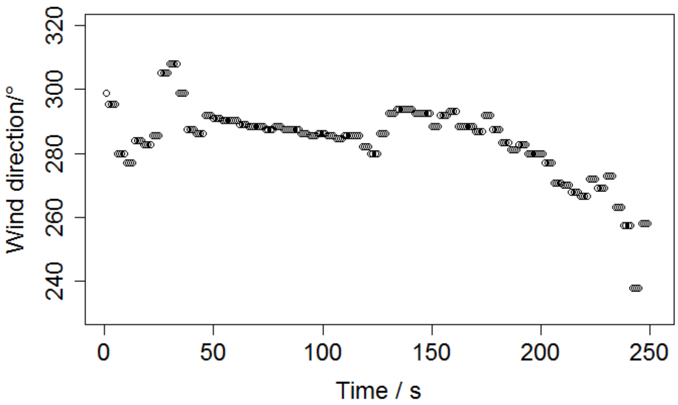

Fig. 5 Changes in wind direction

3.2 Influence of Flight Control and Attitude Parameters.

Aircraft flight control system is used to convey manipulation instructions, driving rudder movement of all components and the general term for the device, for aircraft flight attitude, speed and track control. The aircraft in the air operated mainly by the elevator, aileron and rudder three control surfaces to rotate, the three control surface, under the action of airflow, will produce the operating torque of the aircraft, which rotates around an axis and a longitudinal axis and vertical rotation, thereby changing the attitude of the aircraft flight. The motion of the X on the horizontal axis of the aircraft is called pitching motion. The angle formed between the plane and the horizontal plane is pitch angle, and the regulation is upward and downward. The motion of the Y on the vertical axis of the aircraft is called roll motion. The angle formed between the plane and the horizontal plane is the roll angle, and the same regulation is upward and downward. The movement of the Z around the vertical axis of the aircraft is called yaw motion. The angle formed between the plane and the vertical plane is the yaw angle. The right direction is set to the right and the left is negative[6].

As shown in Figure 6, the response curves of the elevator and pitching angle change is given, QAR data from intercepting radio height at 2000 feet away from the airport to the main air ground switch grounding's 251 data. As can be seen from the figure, the rudder side of the rudder deflection angle, the provisions of the upward deflection is positive, left and right rudder surfaces are deflected in the same direction. The change of the pitch angle in the approach phase shows a significant change with the deflection angle of the rudder surface of the left and right elevator, and the aircraft moves longitudinally about the horizontal axis.

As shown in Figure 7, the aileron and roll angle change response curves is given. It can be seen from the figure, the rudder deflection angle of left and right aileron, the provisions about the rudder deflection in the opposite direction, in the initial approach phase, the deflection angle of the left and right aileron is obvious, and the roll angle is also obviously changed, so that the lateral motion of the aircraft is kept along the vertical axis.

As shown in Figure 8, the rudder and yaw angle change response curves is given. When the pilot push forward the right pedal, the rudder deflects an angle to the right, and the vertical tail to produce a left additional aerodynamic force, so that the aircraft center of gravity to form a nose to the right deflection yaw moment, the aircraft deflects the heading to the right. Similarly, when the forward pedal left pedal, the direction of the rudder to the left deflection, the aircraft deflects the heading to the left, as can be seen from the figure, the initial approach and the final approach when the steering rudder more frequent, yaw angle with the rudder changes in the location of the corresponding changes, the aircraft around the axis of movement.

In summary, during the flight, the pilot through the flight control to adjust the aircraft attitude, so that the flight state is within a stable range. Pitch angle, roll angle and yaw angle as the response aircraft relative to the ground posture, in the study of the approach to the flight quality is an important factor can not be ignored.

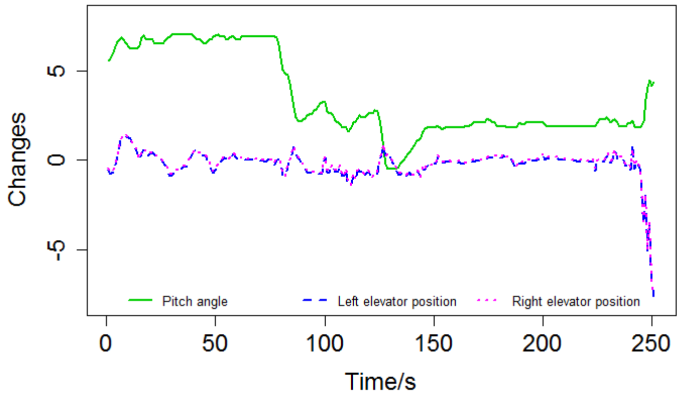

Fig. 6 Response of elevator control

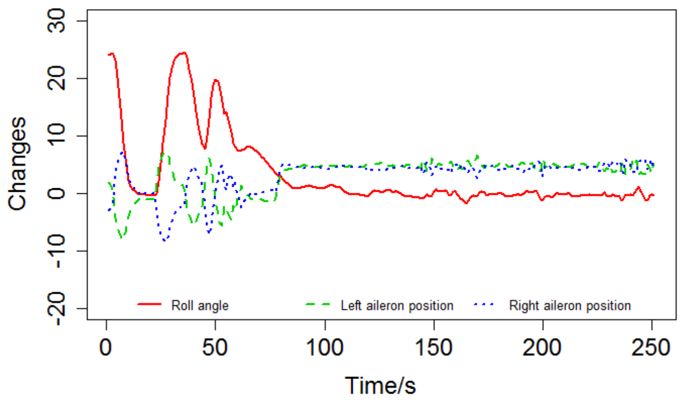

Fig. 7 Response of aileron control

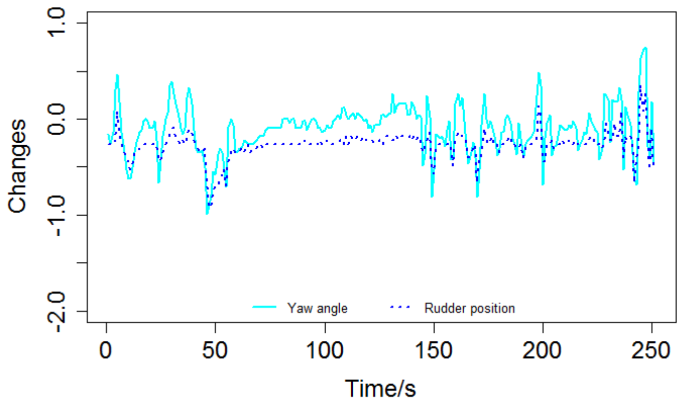

Fig. 8 Response of rudder control

4. Conclusion

In this paper, the radial basis function neural network fitting method is used to preprocess QAR data. Through the QAR data, the influence of meteorological environment parameters, manipulations and attitude parameters on the flight quality of the approach is analyzed emphatically. This study has important reference value for evaluating the flying quality of pilots with QAR data, and it has certain practical significance to guarantee flight safety.

Acknowledgements

Thank you tutor for the guidance of this paper.

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