UDC 656.7.086

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Procedure for using the analysis of the spectrum of autocorrelation functions of the controlled parameter by aviation specialists

The method of analysing the spectra of the controlled parameter was used in the study. As a result, this method makes it possible to outline the moment of origin of the pilot's emotional disturbance, build a function of influence on the quality of piloting technique and develop a methodology for a crew-training programme to minimise the stress load.

Data sampling and problem statement

The technical operation of aircraft depends not only on the serviceability of aircraft and ground equipment, but also on the professional training and psychophysiological state of the crew.

The study was based on the results obtained in the article [1]. For this study, we formed a sample of flight values of pitch angle at the landing stage. In addition, we decoded the flight data of real flights for several pilots (Fig. 1).

$$\theta := \begin{pmatrix} 4.2 & 4 & 3.8 & 3.5 & 3.2 & 2.9 & 2.5 & 2.1 & 1.5 & 0.7 & 0 & 0.5 & 0.9 & 1.2 & 1.6 & 1.9 & 2.3 \\ 2.4 & 2.7 & 3.1 & 2.9 & 2.5 & 2.7 & 2.1 & 1.7 & 2 & 1.2 & 1.7 & 1 & 1.4 & 0.5 & 0 & -0.4 & -1.2 \\ -1.1 & -1.4 & -1.6 & -1.8 & -1.6 & -1.3 & -0.5 & 0 & 0.5 & 0.7 & 1.1 & 1.5 & 1 & 0.5 & 1.2 & 1.7 & 1.9 \\ -1.6 & -1.9 & -2.1 & -2.3 & -2.1 & -1.8 & -1.3 & -1.5 & 1.8 & 1 & 1.2 & 1.5 & 0.7 & 2.1 & 1.5 & 1.3 & 0.9 \\ 0.5 & -1.2 & -1.8 & -1.2 & -1.5 & -0.4 & 1.9 & 1.5 & 1.2 & 1.1 & 0.9 & -1 & 1 & 0.3 & 0 & 0 & -1.2 \\ 1 & 0.9 & 0.7 & 1 & 0.5 & 1 & 0.9 & 0.8 & -1 & 0 & -0.5 & -1.2 & -1 & 0 & -0.5 & -1 & 0 \\ 1 & 1.2 & 1.4 & 1.7 & 2.1 & 2.5 & 2.7 & 2.9 & 3 & 3 & 3.1 & 3.2 & -3.1 & 3.3 & 3.5 & 3.4 & 3.5 \end{pmatrix}$$

Fig. 1. A sample of flight information transcript

In a flight simulator, it is difficult to simulate stressful conditions that could bring the pilot's psychophysiological state closer to a real flight. This is due to the absence of dangers present in real life. The simulator can only work out situations to develop sensorimotor skills.

This paper examines the relationship between the pilot's psychophysiological state and the quality of landing in real conditions by analyzing the spectra of the autocorrelation function.

The autocorrelation function allows determining the degree of correlation between individual elements of a time series represented as a random process. In this case, such elements are pitch angle values.

There are the listings of calculations of the spectra of the normalized and non-normalized autocorrelation function performed in Mathcad.

$$S_t := \sum_{i=0}^{24} \left(K_i \cdot e^{\frac{-i \cdot 2 \cdot \pi \cdot i \cdot t}{33}} \right) \quad (1)$$

$$S_t := \sum_{i=0}^{24} \left(\Psi_i \cdot e^{\frac{-i \cdot 2 \cdot \pi \cdot i \cdot t}{33}} \right) \quad (2)$$

All calculations are based on the decoded flight data of the Boeing 737 NG aircraft. Consequently, we perform calculations using formulas 1 and 2.

As a result, we obtain graphs of the distribution of autocorrelation function spectra (Fig. 2)

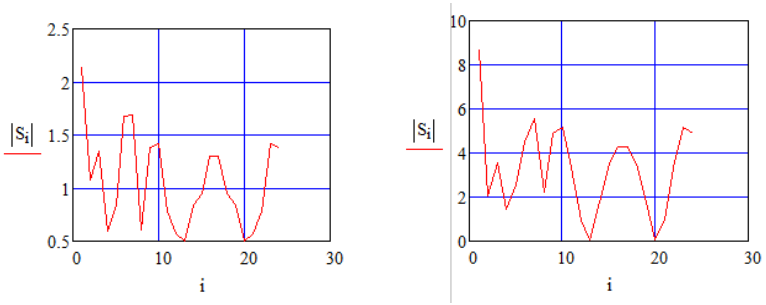

Fig. 2. The spectrum calculation of normalized and unnormalized autocorrelation functions

Since flight conditions cannot be simulated on a simulator, an important factor in this study is that all data are taken from real flights.

The analysis of the spectra of autocorrelation functions of the controlled parameter makes it possible to identify the impact of increasing psychophysiological load on this parameter.

The study of the dependence of the impact of stress factors on the pilot's psychophysiological state makes it possible to make decisions to reduce this impact and improve the quality of piloting. Since the quality of piloting deteriorates due to an increase in the amplitude of pitch angle fluctuations up to values that may exceed the maximum permissible values, it is proposed to introduce a system that monitors the pilot's stress level and, based on these data, displays warnings and/or reduces the level of these fluctuations.

Conclusions

Landing an aircraft is the most difficult and responsible stage of a flight. The processing of a large amount of data by the pilot is one of the main stressors. Combined with the limited amount of time available for data processing, the pilot's psychophysiological state is worsening.

Therefore, it should be noted that the quality of gliding piloting depends on many factors that are either permanent or random. In particular, deteriorating weather conditions are a less controllable factor than the pilot's professional training. The methodology for studying the pilot's psychophysiological state is to measure the increase in pitch angle amplitude.

This way, controlling the deviation of one of the flight parameters allows us to make conclusions about the development of a stressful situation and take measures to reduce it.

The main goal is to develop an effective method for reducing the impact of stress factors on the crew, preventing the development of dangerous situations at the landing phase, and implementing it in the pilot training program.

References

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