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# The development of individually-adapted neural network model of "pilot-aircraft" system using modern aircraft simulation facility

R.V. Kim[a], V.A. Yakimenko[a], E.A. Burlak[b]*, A.M. Nabatchikov[b], A.A. Jatsko[c]

[a]*Moscow Aviation Institute (National Research University), Moscow, Russia*
[b]*State Institute of Aviation Systems, Moscow, Russia*
[c]*Bauman State Technical University (National Research University), Moscow, Russia*

**Abstract**

The results of the study of the individual characteristics of pilots control actions in landing mode are presented. The study was carried out with the use of MiG-AT aircraft simulation facility. It is shown that the pilot inherent individual style of controlling aircraft in landing mode can be described with the individually adapted neural network model. This model for any moment of performing landing mode is specific to the pilot and presents correlation between the current state vector of "pilot-aircraft" system and predicted aircraft deviation from the Ideal landing coordinates. The simulation of landing trajectories on MiG-AT aircraft simulation facility was performed with the assistance of a group of operators who had different experience and qualifications. The results of these studies suggest that a particular characteristic of the pilot to control the aircraft in landing mode is uniquely manifested in the architecture of the neural network, the values of its parameters and the composition of the input signals.


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*Keywords:* individually adapted neural network; "pilot-aircraft" system; aircraft simulation facility; landing mode; operator; control.

## 1. Introduction

Implementing systems to support the pilot in the airborne equipment of modern aircraft is one of the promising areas of the solution to reduce the number of fatal accidents and increase safety.

* Corresponding author.
*E-mail address:* burlak@gosniias.ru


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The main function of the systems of this class is to develop in the course of the flight the pilot recommendations based on the analysis of the current flight situation. Introducing the pilot recommendations should stimulate him to the exercise of such control actions that would ensure the successful implementation of the tasks of the current flight regime. One of the key factors affecting the efficiency of the support system is the feasibility of forming the recommendations. In other words, the pilot must have the opportunity to be able to perform control actions corresponding to the recommendations issued by the support system. This fact suggests that the formation of the recommendations must consider not only the current flight situation, but also the characteristics of the pilot.

There are different approaches to the simulation of the pilot activities, each of which has its advantages and disadvantages. The most commonly used ones are the model in the form of a transfer function with constant coefficients[1], the optimal pilot model, based on the principle of minimization of energy consumption management model A.A. Krasovsky, minimizes the functional of the generalized work[1]. These models parameters may be drown from experimental data by parameter identification technology widely used for aircraft parameter estimation[2,3]. In general we can say that the common disadvantages of these models are the complexity of accounting for the impact of uncontrollable factors of a random nature and, as a consequence, lack of reliability of the traffic forecast and assessment of possible successful solution of the target. It should be noted that the presence of random factors can be due to the influence of the external environment and fluctuations in the dynamic characteristics of the aircraft, and the deviations of the parameters governing the reaction of the pilot caused by changes in its physiological condition and qualifications.

## 2. Reasons for use of individually adapted pilot models

The above circumstances lead to the need to develop and use continuously adjustable individually-adapted models reflecting the nature of control of the aircraft to a specific pilot on a specific time interval of its professional activities[4].

The study was carried out with the use of MiG-AT aircraft simulation facility[5,6,7]. In the process of processing of results of bench simulation was conducted to check the following statements: 1) in the course of professional activities at the pilot generated a certain stereotype of behavior, which manifests in his usual manner of flying and is reflected in the parameters of the trajectory and control parameters of the aircraft; 2) the manner of piloting of different pilots may be different from each other. The experiments involved two operators with different experience of flying on a hardware-software simulator. The choice of the mode of landing for the study was due to the fact that it is characterized by a high level of regulation governing the actions of the pilot. Thus, if these fairly stringent conditions will reveal individual differences in the implementation of the landing trajectories of various pilots, it is possible with a high degree of certainty that the individual manner of driving would occur while performing other flight modes. During the study, each of the two operators performed for 50 landings, in which were recorded the parameters characterizing the motion of the center of gravity of the aircraft, its angular position and control performed of the pilot.

To check the formulated statements were analyzed the statistical significance of differences between values of control parameters corresponding to the trajectories of different operators. First, using Kolmogorov-Smirnov[8] it was found that the distribution of investigated parameters do not belong to the normal distribution. To test the first claim was used rank-based Wilcoxon test for two dependent samples. The sample was formed as follows: the data accumulated as a result of performing a single operator 50 landing modes, separately for each of the recorded parameters were divided into two samples, the first of which were results of the landing regime in the first 25 flights, and the second contained respectively the implementation of the parameter obtained in flight with 26th to 50th. The comparison of the thus formed sample of the aggregates was conducted for each parameter at several fixed points of the trajectory corresponding to the following fixed values removal of the aircraft from the centre runway (RWY): $l = 5000m$; $l = 4000m$ ; $l = 3000m$ ; $l = 2000m$ . The results of the evaluation of differences between samples is shown in table. 1. The table shows the calculated significance levels in Bold for the parameters where statistically significant differences for different periods of activity of the operator were observed.

From these data we can conclude that at a greater distance from the runway the operator's individual style of management is not enough expressed, as evidenced by the presence of a number of parameters whose values show statistically significant differences for different periods of activity of the operator. However, since the removal of