Some Questions of Differential and Topological Diagnostics

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In this paper, the motion of an aircraft is described by nonlinear ordinary differential equations. Based on these equations, the probable malfunctions in the motion control system are classified, the concepts of reference malfunctions and their neighborhoods are introduced, the mathematical modeling of these malfunctions and their neighborhoods is carried out, the concept of diagnostic space is introduced, and the mathematical structure of this space is defined.

The problem of diagnostics is stated for the motion control system of an aircraft. The problem of diagnostics is represented in the form of the following two problems, which are solved sequentially: the checking problem, that is, the problem of detecting the malfunctions in the control system, and the diagnostic problem, that is, the problem of tracking a particular fault that has occurred. The faults are detected in the course of the aircraft's functioning.

In solving the checking problem, the concept of checking surface is introduced. The criterion for a malfunction is the attainment of this surface by a state trajectory. Methods for constructing the checking surface are presented.

The diagnostic theorem is stated and proved. Based on this theorem, we propose extra-trajectorial algorithms for solving the diagnostic problem for the malfunctions that have occurred in the diagnostic space, i.e., in the aircraft's motion control channels in the case under consideration. These algorithms are used once the state trajectory has attained the checking surface or in the process of uninterrupted express-diagnostics.

The extended checking and diagnostic problems as well as the general problem of diagnostics are stated; it is shown that solutions to these problem do exist.

The problem of diagnostics is statistically solved for the case of noise-corrupted trajectory measurements; the noise is taken to be a stochastic process of normal white noise with zero mean value and bounded spectrum. Moreover, the diagnostic functional is obtained under this procedure. Earlier, this functional was chosen in advance. The minimization of the functional thus obtained yields the diagnostic algorithm obtained earlier.