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APPLICATION METHOD INERTIAL NAVIGATION SYSTEMS TO ENHANCE THE SAFETY OF AIRCRAFT NAVIGATION

Inertial navigation systems are the basis of navigation complexes of modern moving objects [1, 2]. This is due to the fact that they provide complete information about the navigational parameters of the movement - course, trim, roll angles; acceleration, speed of movement and coordinates of the location of the object [3, 4]. At the same time, they are completely autonomous, that is, they do not require any information from the outside. Due to the ability to determine the angular position of the object with high accuracy in any range of angles and with a high frequency of information output, inertial navigation systems have no alternative, especially in the absence of their own satellite network [5, 6].

Practical implementation of inertial navigation methods is associated with significant difficulties caused by the need to ensure high accuracy and reliability of operation of all devices at given weights and dimensions [1, 3].

Increasing the accuracy of navigation of moving objects is associated with the improvement of both measuring equipment and mathematical support for solving information processing problems [2, 5].

The use of inertial methods under the influence of the Earth's anomalous gravitational field in promising aircraft navigation systems requires a deeper study of the possibilities of stochastic models of the anomalous gravitational field, which coherently describe the anomalies of gravity, geoid height, and temple deviation [4]. The choice of which models should be based not only on the requirements of adequacy to the real field, but also on the convenience of their use in information processing tasks [1, 6].

In connection with this, an urgent scientific task arises in the field of aircraft navigation: the synthesis of methods of using inertial navigation systems in flight conditions.

The complex structure of errors of navigation systems as functions of time, the uniqueness of their implementations, is caused by the influence of a number of unaccounted factors that require the use of models of random functions for their description.

At the same time, the navigation system errors contain components that do not have ergodic properties and have, for example, the form of known functions of time with parameters that change from one system launch to another. It should be noted that the question of the meaningful introduction of the probability space is not only methodological in nature, which ensures the mathematical correctness of the analysis, but also reveals the meaning of the averaged accuracy characteristics that should be used in the tasks of analysis and synthesis of navigation systems.

At the heart of modern approaches to information processing and management tasks are processes that are the solution of linear differential equations with random initial conditions and the right-hand side containing random functions of the white noise type and represent a special class of random processes that are solved using stochastic differential equations.

The transition from one differential equation of higher order to a system of stochastic differential equations of the first order, written, for example, in the normal form, completes the task of describing the errors of the navigation system in this case.

Each of the navigation system errors in aircraft flight conditions is characterized by the fact that they are dependent on several parameters. We will call the generalized concept of a random process, which is a function of several arguments, a random field.

The need to use a pulsating filter is caused by the desire to reduce computational costs when filtering a navigation signal with a possible change of the model number from step to step of discrete time.

The interpretation of the unknown parameters of the signal model as random variables is, as a rule, conditional; the considered approach is no more than one of the evaluation methods, which reduces the problem of adaptive processing to the problem of optimal filtering. Moreover, the effectiveness of the adaptive procedure built on this basis turns out to be significantly dependent on the degree of influence of the species and density parameters on the result of the estimation of the vector of navigation parameters. It is clear that the estimation of navigation parameters will be practically satisfactory only if the influence of density on it is weakened due to the use of measurements. It is easy to see that the extended state vector of the flight parameters satisfies the stochastic finite-difference equation, which makes it possible to use the recurrence relation for the posterior density of the vector of navigation parameters to solve the problem.

The considered adaptive algorithm, based on the discretization of the vector of uncertain parameters, is easily generalized to the case when the a priori uncertainty consists in assuming the possibility of describing the signals to be processed using one of the models that differ not only in the numerical values of the parameters, but also in their structure. Indeed, understanding the number of one of the alternative hypotheses about the signal belonging to the corresponding model, we come to the solution of the problem of optimal estimation of the vector of navigation parameters, which is of interest to us in the conditions of uncertainty of the corresponding model number.

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