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Methods of Information Processing of Relative Motion in the Flying Groups of UAV

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ABSTRACT

In this article, the author investigates information processing algorithms in order to determine the relative UAV motion parameters in a group flight and proposes an algorithm for estimating the leading UAV motion parameters from the results of relative motion measurements. Such researches are especially important nowadays in all the spheres where the drones are used and/or will be used. The author considers the problems of management of the UAV in the group flight, formulation of the problem for processing of the information in such the conditions. The article considers relative motion equation and the synthesis of information processing algorithms in the master-slave model of the flying group of UAV.

KEYWORDS

Group Flight, Information Processing, Relative Motion, UAV

INTRODUCTION

Currently, there is an increase in the level of interest in unmanned aerial vehicles (UAVs). UAVs are freely used around the world. UAVs, as a rule, have only two main purposes: scouts and targets. To date, the UAV for the application and capabilities of UAVs has expanded significantly, there are many new challenges for existing and promising UAVs, both military and free. For example, the use of weapons (Predator), hours-long flights ("Global Hawk"), agricultural tasks, etc.

In this series, one of the most important is the task of ensuring group UAV flight. When solving it, a number of significant technical problems arise, the search for solutions to which are currently being carried out in a number of countries. The existing developments in the field of automatic control of group flights of UAVs so far have focused mainly on the control of the system of manned aircraft with long ranges between them, and for UAV, flight requirements are put forward in flight with distances and intervals of 10-100 meters.

In this article, the author investigates information processing algorithms in order to determine the relative UAV motion parameters in a group flight and proposes an algorithm for estimating the leading UAV motion parameters from the results of relative motion measurements.

The modern development of aviation has set the task of performing a joint flight of a group of unmanned aerial vehicles. In this regard, the task of managing UAV in a group with high accuracy is of particular importance. The need to develop UAV flight technology in the ranks is currently putting forward a very important direction: the creation of inter-aircraft navigation systems (IANS) for UAVs with very limited weight and volume. This need is also determined by the fact that the absence of UAV IANS in on-board equipment can significantly limit their capabilities in some cases.

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For several reasons, the task of automatic flight control of aircraft in a group manner is one of the most complex and specific scientific and technical problems of aviation, requiring a comprehensive solution. It consists in the need for tactical substantiation of rational types of lines, the number of UAVs in a group, in determining the ideology of collecting UAVs in a group, in choosing methods for synchronously controlling each UAVs of a group to ensure flight safety and for each UAV group to maintain their place in the ranks in straight and curved sections flight of the whole group as a whole. Moreover, the ability to control the group is complicated by the unsteadiness of the flight parameters. UAV management methods define the basic principles that are used in the design of UAV control systems in a group.

It is clear that to ensure the necessary accuracy of the flight control process, UAV IANS should be built in the form of a system with feedback on information about the relative position. This allows, from a single point of view, to consider the UAV flight control system in the ranks and give a unified mathematical basis for its description. UAV flight control automation in a group order is associated not only with the development of theoretical flight fundamentals, but also with the development of on-board technical means for measuring relative position and control systems. The analysis of the state of the means for determining mutual coordinates showed that none of the existing and currently being developed measuring tools provides modern requirements for determining mutual coordinates in dense groups.

The creation of instruments for measuring the relative location of UAVs in a group does not completely solve the problem of ensuring UAV flight operations. It is also necessary to solve the problem of automating the processing of information on the parameters of relative motion and flight parameters in order to form control algorithms. Due to the complexity of the task, various approaches to its solution are possible, differing both in the distribution of control functions between the ground control point and the board, and in the choice of principles that can be taken as the basis of the control system and which determine its structural and dynamic characteristics.

The mathematical basis of the methods for solving the problems of inter-aircraft navigation considered in this paper is the theory of estimation and filtering.

An analysis of a number of works shows that their results are focused on the construction of IANS for flight in formation with long ranges between them and therefore cannot be fully used in UAV IANS, since they put forward the requirements of flight in formation with distances and intervals of 30-150 m. In these works, the problems of choosing the control structure and its parameters, studying dynamics and stabilization accuracy taking into account non-linearities in the UAV mathematical model and the model of relative motion were not fully considered. At present, standard IANS algorithms are not developed, as is done in navigation. Therefore, the task of developing algorithmic support for UAV flight, including UAV in operation, is very relevant.

The development of the IANS goes in two ways: the creation of autonomous systems that are not dependent on terrestrial facilities, and systems using terrestrial beacons. Each of these paths has its own advantages and disadvantages. The second way has one of the drawbacks associated with the accuracy of determining the mutual coordinates of UAVs moving in a group, which does not allow using this principle for UAV flight in dense group orders. Thus, errors in determining the relative position of UAVs in a group can reach values of 30-400 m depending on the distance to the beacons (for example, modern radio navigation systems can determine coordinates with an accuracy of 0.13 - 1.3 km). At the same time, this ideology can be applied for the flight of a large number of UAVs over several UAVs in dense groups, moreover, these UAV groups can be among themselves at distances of up to tens of kilometers (on the principle of “leading with leading”). Another and main disadvantage of this path is that it provides UAV driving in group orders only within the line of sight of radio beacon systems.

According to some experts, the use of ground-based equipment for automatic flight control of the UAV group is technically easier to implement, does not impose restrictions on the weight, volume and operating conditions of the equipment. However, these conclusions are not convincing enough,

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