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QUALITY CONTROL OF DRONE DEVELOPMENT BASED ON TESTING AND FLIGHTS SIMULATION PROGRAM

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Abstract

With the development of the Internet of Things, research is increasingly being carried out aiming at creating a group of unmanned devices that interact with each other and make a joint decision to achieve a set goal. One of the branches of such research is the organization of an ensemble of drones. An ensemble of drones is a set of unmanned aerial vehicles aimed at achieving a common goal without human participation in piloting them. When organizing such interaction, a lot of highly specialized tasks appear that require solution. One of the options for solving such tasks is the creation of a computer flight simulation program and testing of components of unmanned aerial vehicles. The work describes the requirements for this software tool, as well as the minimum functionality that it must have. Thanks to this tool, many tasks are solved that greatly contribute to the development of this industry. Also, the introduction of a computer testing program will improve the quality of the drones produced by means of testing the system components at the early design stages. By creating this software tool and successfully passing virtual tests, the problems that complicate the development of high-quality drones will be significantly reduced.

Keywords: Drone, automatic flight, simulation program, drone control quality, drone ensemble

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1. Introduction

Nowadays, the question of implementing the concept of interacting devices is being raised increasingly. First of all, this is due to the fact that there is an urgent need to exclude the human factor when solving tasks of controlling such devices. For example, if all cars become interacting devices in the piloting of which no person is involved, then it will be possible to avoid road accidents and solve the problem of traffic jams. Thus, this subject is extremely relevant and requires careful study.

2. Problem Statement

When managing the quality of drone development, it is necessary to provide a number of important functional parameters, one of which is the management of an ensemble of drones. At the moment, all flocks of unmanned aerial vehicles are many devices that do not interact with each other in any way. If we consider drone light shows as an example, then in such shows all devices move according to the pre-set GPS coordinates (Mokronos, 2020). The flight trajectory of each drone is controlled by a special computer program. Accordingly, the drone during the piloting process does not differ much from a conventional quadcopter. This circumstance does not in any way come close to solving the problem of interaction in a flock of unmanned devices, when many tasks can be solved without the direct participation of the user. When developing drones, it is required to achieve such a result in which unmanned aerial devices will be able to receive new commands and home coordinates, regardless of the connection with the control base, and quickly begin their implementation.

3. Research Questions

In the course of the study, the following issues were considered:

- the main tasks when organizing an ensemble of drones were studied;
- how one can solve most of the difficulties in the ensemble of drones;
- what is required to develop programs for virtual simulation of drone flight;
- why the introduction of a computer simulation and testing program will improve the quality of development of unmanned aerial vehicles.

4. Purpose of the Study

The purpose of the work is to improve the quality of the development of drones, aimed at ensuring the operational control of their interaction. The tasks of developing a computer simulation program and testing the drones' hardware are considered, as well as the features of their flight and interaction in a flock, which should have a beneficial effect on the quality of the final product.

5. Research Methods

Let us analyze the main tasks that need to be solved in order to implement an ensemble of drones:

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- design of the device;
- hardware component;
- software component;
- data exchange between devices;
- device testing program.

5.1. Design of the device

Modern drones are complex technical devices that contain almost all the components necessary for organizing data exchange. Of course, wireless components of data transmission, processor, software will not be able to implement the reception and processing of information. However, the refinement of several elements greatly simplifies the process of creating such devices, rather than designing from scratch. The main task in this direction is the selection of a productive processor, made according to the 10 nm process (or higher), which will provide high performance and low power consumption (Intel Pro 10 nm: Nature is stronger than nurture (database), 2021). You also need to implement the simultaneous connection of multiple devices and the exchange of data. The most difficult task will be to develop the software for such devices.

5.2. Hardware component

As already noted, for the implementation of an ensemble of drones, it is necessary to replace the devices for transmitting and receiving information, as well as the data processing device (central processor). Regardless of the choice of frequency and data transfer protocol, there will be a problem with the maximum number of simultaneously connected devices. However, specialized signal repeaters can solve this problem. The central processor of modern drones is quite productive, it is not difficult for it to process and store high-definition video (DJI FPV Racing Drone: Overview and Features (database), 2021). When such processor is assigned new responsibilities for processing a large amount of input data, then with a high degree of probability it will not cope and will malfunction. To solve this problem, one can introduce new generation processors from Qualcomm or MediaTek. Since recently, the Russian Federation has started developing its own production of "Baikal" central processors (Review of "Baikal Electronics" processors. Characteristics and advantages (database), 2021). Thus, the use of Russian components of the system is quite likely from the point of view of the hardware heart of the device.

5.3. Software component

The software component of a drone is a difficult task to implement, requiring a large number of issues to be solved. So, it is required to develop new software for the interaction of the processor with new components. It is possible to design a new motherboard, which will significantly complicate the task. From the point of view of the development of information technologies, it is possible to introduce artificial intelligence built on neural networks. Unfortunately, this will not guarantee full functionality, and the learning process can take a long time. Accordingly, in the current realities it is planned to use simple logical methods of design and behavior of each individual device. According to the research of Aleksey Redozubov

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(Artificial intelligence, strong and not so much (database), 2021), a structure consisting of many simple objects is complicated many times over. This fact applies well to drones as well. Thanks to this, it will be possible to use drones without artificial intelligence.

5.4. Data exchange between devices

From a hardware point of view, exchanging data between drones is not such a difficult task as understanding what information needs to be transmitted, how to process and interpret it. Without a doubt, all flight information regarding speed, angle of attack, gyroscope, GPS and GLONASS must be transmitted and accounted for the mission. However, when it comes to information related to non-flight data, there are many nuances and incomprehensible situations. For example, how should a flock of drones act if one of them transmits information about an impending collision hazard (bird or tree). In the first scenario, the drones must immediately fly apart to prevent a collision. In the second scenario they somehow have to make sure whether there is actually a danger of collision. If we assume the first scenario, then due to constant displacements and rearrangements, the integrity of the drone flock will be constantly violated, and the battery will unreasonably quickly use up its charge. If we assume the second scenario, then how exactly should they confirm or deny the danger. On top of that, it can take too long to confirm the danger, which can lead to a collision. Unfortunately, there can be a large number of such moments and variations, which greatly complicates the organization of data exchange between devices and programming actions for each of them.

5.5. Device testing program

Drone testing is an important criterion for the quality and reliability of its correct operation. However, carrying out large-scale tests is very resource-intensive, both financially and time wise. As noted earlier, there are no ready-made drone options for this task on the market. Because of this, it will be necessary to carry out certain work on revision and further debugging. Making one such drone will require a large amount of material and time resources. When it comes to an ensemble of such devices, all expenses are multiplied. This leads to a problem when an idea at the design and analysis stage requires significant investments, but does not guarantee 100% success. Even the largest companies are unlikely to go to such expenses without any guarantees of development success. In order to show the principle of interaction of such devices, as well as to conduct a number of initial tests, it is required to design and develop a computer simulation program for the operation of a drone.

A drone computer simulation program has two main tasks:

- designing and testing the interaction of drone components;
- organizing an ensemble of drones and assessing their behavior depending on various input data.

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6. Findings

The development of a new generation of drones will require the refinement of many of its components, as well as the installation of additional equipment. Since all elements will be based on a single control board, a conflict of structural elements is quite likely. It is simply impossible to say right away where problems may arise. To do this, one will need to recreate the drone with all the components in a specialized computer program. At the moment, there are products on the market that allow designing logical elements and their structure. Unfortunately, almost all of them are broad spectrum programs meant to design simple systems. Also, their disadvantage is the poorly developed testing module for the finished device layout. Multisim is an example of such programs (Multisim general-purpose simulation program (database), 2021). To solve the problem of element-by-element testing and the operation of the drone, one will need to develop their own program, which will allow both decomposing the device into microcircuits and transistors and considering the direct interaction of components on the control board. Thanks to this, it will be possible to study each signal and command arriving at certain components. This will allow studying with great accuracy the behavior of all components for various scenarios of the finished device. Also, thanks to such a computer program, it will be possible to solve the issue of testing the drone when one or more of its components fail and provide for possible options for error management. This becomes possible due to the fact that any drone is a finite state automation (Trofimov, 2019). Based on this, it will be possible to recreate the work of each element from the point of view of a state automation. Certain difficulties are caused by the fact that any quadcopter uses a large amount of memory, which also affects the number of possible states of the automation. Proceeding from this, another task appears - the study of the drone functioning process as a finite state automation with a large amount of RAM and permanent memory. At the moment there is no answer as to whether the memory can be neglected. If you can eliminate the memory factor from the design of the drone, then it will be possible to significantly simplify the problem being solved.

If the simulation of the drone components is successful, it will be possible to begin the process of virtual testing of the ensemble of unmanned aerial vehicles. It is not enough to know that the drone is capable of receiving and transmitting data, it is necessary to clearly understand how they react to the input data (Sanchez-Rivera, et al., 2020). In addition, at this stage of testing, it will be determined whether the drones are able to interact with each other, maintain a given formation, and correctly respond to commands and threats. If one tries to focus on the most important points, then the following types of tests should be performed:

- flying in a flock of one row of drones;
- flight in a flock of n number of rows;
- flight in various meteorological conditions;
- simulation of the failure of drone components;
- the average time of signal transmission and processing between devices ($t0 \rightarrow t1 \rightarrow tn$), where t0 is the initial time of sending the signal, t1 is the time until the signal is received by the first drone, tn is the time until the information is received by the last drone;

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- verification of detection and warning of hazards;
- verification and confirmation of the fulfillment of the mission;
- processes and actions during rearrangement and maneuvering;
- flight in case of loss of connection with the base and between devices.

All of the above is a small part of the tests that should be performed before starting the production of this type of unmanned aerial vehicles. Nevertheless, this will be enough to determine how realistic this idea is and what nuances will need to be taken into account.

Thus, the minimum functionality of a software product for computer simulation and testing of an ensemble of drones proposed for development should include:

- checking the performance of components from the point of view of decomposition into structural elements;
- checking the system for constantly incoming signals and the interaction of many components (as well as a possible conflict of elements);
- the ability to check the management of one or more errors in the hardware component of the drone;
- simulation of a drone flight as an independent unit;
- simulation of the flight of an ensemble of drones in ideal conditions;
- simulation of a drone flight in emergency situations and in case of malfunctions;
- behavior when a flight threat appears and confirmation of this threat with collision avoidance options;
- checking for possible conflicts in the behavior of drones in the ensemble, depending on the outgoing data of each device.

Each component of a drone is a complex element that creates a lot of output data about its state, and generates a lot of extraneous signals and pulses in the course of its work, like pulse width modulation, which can interfere with the functioning of other components (Shchagin et al., 2016). Based on this, a thorough analysis is required. When multiple devices, communicating over wireless communication channels, aim in a close space, there will be a lot of interference generated that will tamper with the operation of the entire flock. Thus, as soon as it is possible to achieve a clear interaction of the components of the drone with each other, it will be possible to proceed to testing the ensemble of drones. But before this can happen, there is still a lot of diverse research to be done.

7. Conclusion

Summing up, it should be noted that the era of the Internet of Things is just beginning to enter its active phase. At the moment, it is still impossible to organize an independent ensemble of drones that could fulfill many tasks facing the national economy of the country and contribute to improving the quality of life of the population. Nevertheless, the work in this direction is already being actively carried out. At present, maximum efforts are required to develop a computer simulation program for testing and flying an

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ensemble of drones. Thanks to this program, it will be possible to successfully solve a number of tasks for organizing an ensemble of unmanned aerial vehicles, as well as prove the possibility of implementing this idea.

The work analyzes a number of main tasks related to improving the quality of drones development, including the features of organizing control of their ensemble, and also offers possible options for their solution in the form of developing a computer simulation program, as well as testing components of unmanned aerial vehicles. Successful practical implementation of the approaches presented in this work will significantly improve the level of production of these aerial vehicles.

References

Artificial intelligence, strong and not so much (database). (2021). https://habr.com/ru/post/393071/

DJI FPV Racing Drone: Overview and Features (database). (2021). https://blog.wazza.com.ua/drony/obzory-i-sravneniya/gonochniy-dron-dji-fpv-kratkiy-obzor-i-harakteristiki/

Intel Pro 10 nm: Nature is stronger than nurture (database). (2021). https://3dnews.ru/1005060

Sanchez-Rivera, L -M., Lozano, R., & Arias, A. (2020). Development, Modeling and Control of a Dual Tilt-Wing UAV in Vertical Flight. *Drones, MDPI, 4*(4), 71.

Mokronos, K. K. (2020). Programming technology of a group of unmanned aerial vehicles for autonomous flight. *Youth of the XXI century: a step into the future*, 126-127.

Multisim general-purpose simulation program (database). (2021). http://ikit.edu.sfu-kras.ru/CP_Electronics/pages/soft/multisim/manual.pdf

Review of "Baikal Electronics" processors. Characteristics and advantages (database). (2021). https://bobr.by/news/press-releases/177281

Shchagin, A. V., Bodrova, A. A., Logvin, V. I. (2016). Basic methods of pulse-width modulation. *Science Symbol, 11-1*, 69-72.

Trofimov, E. A. (2019). *Mathematical models with finite accuracy*. ASV Publishing House.