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DRONE HARDWARE AND SOFTWARE DEVELOPMENT AND TESTING QUALITY MANAGEMENT

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Abstract

Today, unmanned aerial vehicles are being actively implemented in all business activities. However, the operator routinely controls the drone. This fact does not allow the use of drones at long distance to fulfil its mission. Market-available unmanned aerial vehicles enable to send a drone via GPS coordinates, but it does not always reach its goal. This fact is associated with many factors, such as weather conditions, the number of potential obstacles, flight zone and much more. Most of these problems can be solved by sending several drones for one operation. Nevertheless, each of them will be autonomous unit that does not interact with other devices in any way. In this regard, it is required to consider the possibility of organizing model of drone suit. Such devices will be able to exchange key information, so choose a joint trajectory of motion and behaviour. Thus, the likelihood of successful operation increases significantly. The article considers the possibility of creating drone suit, as well as some difficulties that inevitably have to be encountered in developing such a model and their possible solution ways.

Keywords: Drone, automatic flight, drone suit, drone control quality, big data.

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1. Introduction

The era of unmanned aerial vehicles (drones), which began relatively recently, not so long ago, also played a large role in modernization of many types of human activities. Drones are used by rescuers, designers, cartographers, delivery services, military forces, in education (Rahman et al., 2018), etc. The drone is universal device that can easily be adapted for different types of activities. Typically, drones are controlled by the operator (drone pilot) from the control panel or smart phone. One may also control the drone in automatic mode by programming destination points at GPS coordinates. The second option enables to fly several drones at once in limited size area. However, this is possible only when specialized GPS repeater is installed in the flight zone, whose accuracy reaches several centimetres (Levandovskiy, 2018). But both methods are problematic to apply in case when one wants to send large group of several dozen drones to large distance at once. Accordingly, it is required to develop new drone control technique taking into account the capabilities of their hardware and software modifications. The creation of such system will improve the quality of drone use in solving many practical problems.

2. Problem Statement

Modern drones are sophisticated technical devices that are equipped with control system having many sensors and cameras. Using smart phone, the pilot may change the motion vector. Available sensors enable the drone to avoid collision with obstacle (for example, approaching bird, tree branch or another drone). GPS drone control technology is used in entertaining light shows, when devices synchronously change positions along predetermined paths to assemble into a certain spatial figure. In these cases, the flight path of each drone is calculated individually. More complex system is used by drones designed to deliver goods. Namely, they are able to avoid the obstacle and can independently deliver the goods to the buyer's door at predetermined coordinates.

At the moment, it may be sent 2-3 drones at certain distance, so that they independently coordinate their position using GPS and avoid obstacles (Dorling et al., 2017). The problem is that with a large number of unmanned devices, each drone will consider a nearby drone as obstacle. In this case, the task of the on-board collision avoidance system becomes multidimensional and more difficult. Particularly, when the GPS signal is lost, airborne drones will inevitably lose their course and will not be able to reach the target. It is necessary to ensure that drones see each other not as obstacle, but as additional source of environmental information. In this case, it will be necessary to implement the possibility of continuous data exchange to ensure their overall coordination and synchronization of actions and create the integrated multiprocessor control system for the entire suit of items. Thanks to this, the system management quality will go to a whole new level.

3. Research Questions

This study addressed the following issues:

Why are drone suits currently difficult to use?

Why is it necessary to ensure the interaction of drones with each other?

Why will the “Big Data" problem occur when drones interact?

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What methods and tools may be used to analyze the arising data?

4. Purpose of the Study

The goal of this article is to consider the possibility to organize drone suits, as well as to study technologies that are necessary for that. It is also necessary to study analysis methods of arising data arrays used for mapping the flight and coordination diagram.

5. Research Methods

5.1. Problems of drone suit using

Today, the drone automatic control development is at beginning. If before there must have been operator that controls this type of aircraft, now there is opportunity to do without it. So, Amazon has already introduced drones that can deliver packages weighing up to 2.5 kg to customers, while doing this automatically. This type of drones was developed by Amazon itself to address the issue of delivery of purchases to customers. This drone is equipped with many sensors, such as visual, thermal and ultrasound. The neural network is responsible for drone training, which enable to avoid obstacles. It is also able to make photographic map of the area and focus on it if the GPS signal is lost. Thanks to this, it becomes possible to return to the warehouse, even if all other sensors have failed. The built-in algorithm enable landing at a safe place when any error occurs in the navigation system (Wilke, 2019).

If we study the control and coordination method of this drone, then we can conclude that each drone is isolated unit that does not interact with others in any way. On top of that, its equipment consists of many expensive elements that make the development and construction of such drone very costly in terms of time and finances. Nevertheless, this information can be taken into account to develop pattern method of drone in its suit. So, implementation of Camcorder can be used not only for recording or transmitting images, but also for motion coordinating of drones themselves. Use of ultrasonic sensors will avoid obstacle, out of sight of it for camera. Nevertheless, if we now place such drones at limited space, then we will get large number of drones that perceive each other as obstacle. This is the main problem in organizing of drone suit - there is no correlation in critical parameters necessary for motion actions and ensuring safety into single system.

Interaction of drones in its suit is key task that currently faces the drone software and hardware developers (Kotlyarov & Tatarinovich, 2016). Thanks to the constant data exchange, it will be possible to ensure synchronized actions during the flight and to consider several devices not as separate elements, but as single system. This solution will improve the quality of drone automatic control and raise it to a whole new level. If obstacle is detected by one or several drones, it will enable to quickly inform the rest of suit drones about it, even if it is not in their visibility of cameras and radar. Thanks to this, it will be possible to make decision on further motion for the entire swarm to minimize the cost of time and energy resources.

5.2. Interaction of drones in its suit model

Interaction of drones is important element for implementation of suit of unmanned aerial vehicles. Thanks to this, it will turn out to make the flight just like flocks of birds fly. When trajectory of swarm of birds is changing, they are moving as single organism, synchronously and without large delays. When

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implementing this behaviour model during change of the drone motion coordination, it will turn out to increase the quality of their control and provide optimal change of trajectory path. It is immediately worth noting that this technology of drone behaviour can help during rescue and intelligence operations in hot spots. If we send one device, it can simply fail, collide with obstacle or be destroyed for a number of reasons. When several devices interacting with each other are sent at once, the probability of operation failure will be reduced.

Direct interaction of drones can be implemented in the following positions:

- RGB, monochrome and infrared cameras;
- ultrasonic, temperature and volume sensors;
- GPS localization;
- gyroscope;
- wireless source.

Thanks to the cameras, drones will be able to transmit images to the staff monitors who need to assess the environment. However, these cameras can also be used for positioning on terrain and overcoming visible obstacles (Nigam et al., 2018). Cameras may be also used for direct positioning among other drones. When drones change its position within the visibility range, based on the internal algorithm, they can also change position, or stay on trajectory. This method can be used for initial positioning among drones. Despite the apparent simplicity, this technology will successfully work with drones that are in immediate visibility (Lee et al., 2016). Nevertheless, it will turn out to raise the quality of drone control to a new level.

Ultrasonic, temperature and volume sensors can solve the problem of limited camera visibility. Thanks to them, it will be possible to create a drone localization zone in all directions. Thanks to this, it will be possible to track trajectory of several drones at once from all sides. Thus, it will be possible to ensure maximum positioning accuracy and synchronization of direction coordinate change. Naturally, it will be possible to identify any obstacle that needs to be overcome.

GPS sensor makes the most accurate calculation of coordinates for approaching a designated target and calculating a flight route. At the same time, it is worth considering the possibility of installing high-precision receivers, which can ensure accuracy of several centimetres. Naturally, it is possible that such devices would have to be designed and developed from scratch. However, the success in development of high-precision measuring devices is already there and is realized by Japanese scientists who were able to measure the time flow rate at different heights of the planet (Rudyy, 2020). If the high accuracy of GPS module may be ensured from the satellite, then not only sensors and cameras will be reliable, but also the current coordinates of each drone in space, its speed and height. Although, it may not be excluded the possibility of developing a special positioning module for unmanned devices. So, the central drone may be used as the reporting point, and others may be positioned based on its position.

Gyroscope is the aircraft's important element. It shall also be highly accurate, because based on its information, the drone will make a decision about its position relative to the horizon. Based on this information, it will be possible to calculate trajectory, angle of attack, and other various information regarding the positioning and flight direction. Information from each drone`s gyroscope is information that must be taken into account when the whole swarm is flying. Based on collected data, this will complement

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the picture about situation and make one or another decision for further actions.

The most important link in interaction of drones is wireless device. Using technology of wireless data transmission, it is possible to transmit and receive key parameters of each drone separately. Based on transmitted data speed and how seamlessly this technology will be implemented, it will be possible to ensure synchronized motions and data exchange about key flight parameters. It is advisable to use D2D (Device-to-Device) technology, which is implemented in devices that support fifth-generation 5G network technology (Militano et al., 2015). Data processing can be assigned to mobile processors, which are built on ARM core technology (Pyatkovsky, 2013). They have sufficient computing power, low power consumption and low cost. Due to timely data transmission and its processing, it is possible to ensure synchronized actions, develop optimal motion trajectory, avoiding collision and fulfilling the goal.

It is worth noting that when drones interact and one of them detects at least one obstacle, it will be possible to program the system for various actions. So, if tall tree is detected in the middle of swarm, it will be possible to fly around it, breaking the swarm into two parts, and then merging it back into a single group. If the obstacle is an object approaching at high speed and with high heat index, it will be possible to scatter in different directions attempting to maximize the distance from the threat source. Additionally, each drone shall rely on its data, as well as those that come as data exchanging between them. Any important information shall be processed by all devices at the same time, so it may be used the request priority system, as is implemented in the processor time task manager.

Thanks to the described methods and technologies, it will be possible to ensure interaction of drones. As already mentioned, this will enable to achieve progress in implementation of autonomous flight of unmanned devices and fulfilment of goals that are now impossible to achieve.

5.3. "Big data" problem in drone suit

With the constant data exchange between drones, large data amounts will be inevitably transmitted. The whole problem is that these data carry critical information. So, they may contain current coordinates, accelerometer data, rotation speed of blades, speed, angle of attack, information about objects from cameras and sensors, and this is far from all information that can be transmitted to analyze the situation and further behaviour model (Oselio et al., 2019). Thus, even one drone transfers a large data amount every second. Accordingly, it is required to develop specialized software that will enable combining of all elements into a single system and data processing from all drones. This software shall be debugged and function correctly, as confirmed by certain tests and analysis, giving the basis for possible improvement of the autonomous aircraft quality. Therefore, the body of information that needs to be processed and analyzed will be collected during the flight. This information will be also required for the neural network training. As it is known, the longer a neural network learns, the better results you can get. It is also an important criterion why it is necessary to collect and process the maximum data amount.

Thus, based on all of the above, it is obvious that when organizing the flight of drones in swarm, it will be generated large data amount, which will have to be processed at the rate of their arrival.

5.4. Big Data analysis for solving of drones' coordination and interaction

To ensure interaction of drones, it is necessary to conduct a number of technical and software tests. This shall also favourably affect the quality of drone automatic control both in one instance and in a swarm.

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As mentioned earlier, the result of such tests will be a large data amount that must be correctly analyzed in order to obtain information useful for further work. It may contain information about how drones initially arrived in a crosswind, detecting obstacles, what the best speed to develop and what angle of attack to choose in different situations. Having collected information from several devices, it will not be possible to immediately find the answer to how to act correctly in a particular case. Accordingly, such data must be analyzed. There are many tools and techniques for data analyzing. Among the possible methods of data analysis, it is advisable to distinguish the following:

Decision trees.

One of the data mining methods is the automatic plotting of decision tree. Decision tree is a way of representing the rules in hierarchical, sequential structure, where each object corresponds to single node that provides a solution (Akobir, 2019). Generally, the decision tree is used as forecasting and classification tool when making decisions. The most important task in decision tree plotting is to determine the value of objective function when setting a specific data array at the input. When plotting decision procedures based on decision tree, there are also used so-called classification rules. They consist of two parts: conditions and conclusions and are recorded as: if (condition) then (conclusion).

The condition is the result of checking one or more independent variables that can be combined into logical expressions using logical operations AND, OR, NOT. The conclusion is the value of dependent variable or the distribution of its probability by class. The main advantage of logical rules is the ease of their perception and writing in a natural language (Makarychev & Afonin, 2018).

Random forest.

Random forest is suit of certain number of random trees that are slightly different from each other. By composing compositions of trees and combining their results, you can get a quality solution. Random forests can be used for classification and regression tasks. The first papers based on heuristic procedures and devoted to suits of trees date back to the 90s of the last century. The random forest method got its name due to the fact that during plotting the trees used in it is implemented randomness, which gives uniqueness to each tree. Before you start plotting a random forest model, you need to determine the number of trees (Treboux et al., 2018).

Solution for linear and polynomial regression problem.

To solve the regression problem, you can use Linear Regression and Polynomial Regression functions. They ensure the processing of source data numerical attributes. The Akaike criterion is used for model selection. It is relative reliability measure of statistical model compliance and is based on the informational entropy concept. In fact, the criterion sets the relative measure of information loss when this model is used to describe reality. It may be said that it describes compromise between displacement and dispersion in model building or between accuracy and complexity of model (Antonov, 2015).

Clustering.

Cluster analysis is a convenient way to identify homogeneous groups of objects called clusters. It is assumed that these objects have similar features, but differ from objects that do not belong to this group. The purpose of cluster analysis is to identify a number of objects that are similar to each other in a certain

set of parameters called cluster variables.

In this section are listed the main methods of data mining were, but naturally it is not possible to list them all. However, even with such methods you can get a lot of useful information from seemingly unrelated data and find various touch points. All this should help to implement the system of swarm of drones and improve the quality of their automatic flight and accomplishment of glorified goal.

6. Findings

The drone suit is a large number of unmanned aerial vehicles, combined into single system, which are designed to fulfil specific goal without direct operator's control.

To achieve the desired drone flight characteristics, it is necessary to ensure interaction of drones with each other

Good interaction of drones shall ensure optimal flight and increase the likelihood of goal achieving.

The drone interaction will result in formation of large data clusters, which must be processed and analyzed.

At the moment, it is possible to analyze large data amount thanks to special tools and methods, which brings implementation of drone suit idea closer.

7. Conclusion

The drone suit is important and necessary tool that will expand the capabilities of automatic unmanned aerial vehicles and increase their control quality. Thanks to the idea of data exchanging between drones, it is possible to achieve their synchronism and search for optimal flight paths to achieve the goal. Such created drone behaviour model will form the large data cluster, which requires processing and analysis. Data mining uses methods and tools enable getting useful information from a large random data amount. The result of all work will be mathematical model of organization and behaviour of drone suit.

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