

**Klymenko Igor**

## **QUADCOPTER MINES DETECTOR**

### **Abstract:**

A quadcopter mines detector is a device for remotely searching for and providing information about explosive objects. The essence of our development is to provide the military with information about the location of explosive devices.

**The urgency of the research** is that in the war and post-war period, farmers need to be given the opportunity to work on the land, but the presence of explosive facilities makes this process dangerous. There are more than 110 million mines in 65 countries in the world, and the problem of landmining is especially important in Ukraine today.

**Our objectives** were the modernization of the detector for mine detection and its integration with the drone, creating a circuit with an infrared transmitter for signal transmission. Moreover, the next steps were writing a code for calculating the coordinates of the object found in a dangerous area and conducting experimental tests of the developed device. After successfully completing all the tasks, we developed a prototype minesweeper quadcopter. Using it, we conducted a series of experiments to improve its performance, so our idea was confirmed in practice.

**The methods we used** were experimental - the creation of a quadcopter mines detector with its test and theoretical - the study of the literature on modern methods of demining.

In two years, we have developed and **patented** two working prototypes and the C++ software product to demonstrate the latest method of detecting landmines. A smaller sample of a working device based on a quadcopter "Tello" was created. The trajectory is programmed in JavaScript in a special application "DroneDlocks Code". Due to their small size and relatively low load capacity, we have created a detector to search for strong ferromagnets based on a reed switch - a device that changes its effect depending on the magnetic field. After successfully conducting an experiment on a mock-up model, we began preparing a new model of our device. The F5 PRO quadcopter, which was much larger than the Tello drone, was purchased. Also, we created a ring of copper wire and soldered the board for the future metal detector. The metal detector has passed a successful test, we have recorded its parameters, such as maximum detection height, operating search frequency, and detection width. It was attached to the drone with 4 ropes that connected the ends of the quadcopter to a wire circle. There have been several successful launches of such a prototype.

Then we started working on developing reception and processing the received signal. An infrared detector was connected to the RobotDyn UN R3 CH340G board to detect the signal. The code is loaded on the board in C++ in the Arduino IDE. The code itself uses 2 libraries, namely "IRremote.h" - to process signals from the phototransistor and "TimeLib.h" - to work with time. In addition to technical innovations, special C++ software was created.

Coordinates are determined on the Arduino board. When the phototransistor receives an infrared signal the program activates. In it, with the help of functions from the library "IRremote.h", we process this signal from the infrared sensor, and then using the library "TimeLib.h" and some written algorithms, we calculate the time to the found object.

With the drone's speed and knowing the time, we can determine the distance overcovered. By understanding the conditionally created trajectory and the parameters of the length and width of the area to be processed,

we can determine the coordinate of the found object using a known distance to it. After the final calculation, the coordinate is immediately displayed on the screen. A mock-up map with landmines markings is also created, which is superimposed on the satellite photo for ease of use by specialists.

Thus, the novelty of the method lies in the latest algorithm for remote finding the exact coordinates of explosive devices:

1. Start of the mission: set the parameters of the width and length of the area to be processed, after which the code on the drone creates the desired trajectory;
2. The drone flies up and starts going in a special direction by the program which we created for it, also the code on the Arduino board starts running;
3. The drone moves along a given trajectory;
4. After detecting explosive objects metal detector turns on the infrared diode;
5. The phototransistor placed on the board receives this signal and transmits information about it to the board;
6. The execution of the code on the Arduino board begins: according to the known speed of the drone and the time of movement to the found object, you can determine the coordinate comparatively to the start of movement;
7. After the device passes the entire planned trajectory, it returns to the starting point.

The project is open to improvement, as it can be used for mass demining, monitoring of agricultural companies' lands, and also during military tactical movements. Moreover, the drone can be equipped with a radiation detector and used in any dangerous place for humans.

Today we are actively involved in the implementation of our idea in real life, looking for investors and working with specialists and specialized companies. It is planned to use an octocopter and a minedetector with the discrimination of unnecessary materials. Also, the device will be improved by creating a 3D map of potentially explosive objects for ease of use by professionals. The drone with an autonomous operating time of 60 minutes will be able to move a distance of up to 15 km and transmit signals. Detection of the landmines takes place at a depth of up to 0.5-2 meters, depending on the size of the metal parts of the explosive device.

We estimated the cost of sales of MVP is 40,000 USD, whereas the cost of the finished device is 20,000 USD. Thus, we have created a phased plan to enter the market 20-24 months after the initial deposit. The type of market will be B2B and B2G, we will provide monitoring services to small and medium-sized businesses and supply large companies and the government with our devices.

The use of a quadcopter mines detector has 4 main advantages over classical methods:

- Reliability - replacing people with autonomous technologies will mix the number of victims
- Speed - the device speeds up the demining process
- Accuracy - the combination of similar technologies to GPS RTC with a drone and the latest detectors provides an accuracy of up to 25 centimeters.
- Saving resources and saving lives - 1 tractor (combine) equals 3 drones (\$ 60 thousand), and 1 life equals 25 drones (\$ 500 thousand).

**Conclusion:** the problems of landmining and modern methods of searching for explosive objects in Ukraine and in the world were analyzed. The latest method of safe and accurate calculation of the coordinates of the object found on the ground is implemented in the written code on the board with a phototransistor. Two utility model patents were written and approved. The mock-up version of the device with a metal detector and a signal transmission board was developed, in which the induction method of searching for explosive objects was implemented. We have started cooperation with the factory "Meridian" named Korolova. Experimental studies have shown the effectiveness of the developed device.

**Keywords:** drone, agricultural area, demining, mine, metal detector, program.