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ROBOT MODEL FOR MINES SEARCHING DEVELOPMENT

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ABSTRACT:

In this article we justify the feasibility of developing robots for mine clearance. Next, we analyze the necessary equipment and choose which specific models to use. Equipment is selected based on the criteria of feasibility, market availability and cost. The article also presents a Connection diagram and describes the process of assembling the layout.

Key words: Mobile Robot, Mine, Mines Searching, ESP32-Cam, Manufacturing Innovation, Industrial Innovation.

INTRODUCTION

In today's world, robotics is becoming more and more influential [1]-[5]. The list of areas where robots are being introduced is constantly expanding [6]-[21].

It becomes completely natural that in the context of an ongoing full-scale war, robots are used to clear mines from liberated territories. Firstly, the use of robots can save people’s lives, that is, they increase the safety of the mine clearance process. Secondly, the efficiency of using robots in many conditions, especially in hard-to-reach ones, is much higher than that of humans. Moreover, human labor cannot compare with the work of a robot, as well as the scale of the territory covered. Latest technologies also bring huge benefits to robots and so on.

It is impossible to overestimate the importance of technological progress in the field of mine-detecting drones and robots. These autonomous systems reduce the risk to human life by detecting and disarming explosive devices in hazardous environments. Continuously improving their capabilities – from improved sensors to increased maneuverability – increases the efficiency and safety of demining operations around the world [22]-[24]. Technological progress allows faster and more accurate detection of mines, reducing the time and resources needed for demining. Ultimately, this not only protects lives, but also helps restore land for agriculture, infrastructure and community development, highlighting the indispensable role of technology in humanitarian efforts.

Explosive objects cause enormous damage to people's lives and health and to a large extent hinder the harmonious development of human society [25]-[28].

Examples of mine clearance robots include autonomous vehicles, drones, underwater vehicles and robotic arms. Modern models can not only detect mines, but also perform complex operations to neutralize or remove them.

Thus, the use of robots for searching and clearing mines remains relevant because it combines technologies of safety, efficiency and humanitarian assistance, which makes this approach preferable in the modern world. In this case, various methods and approaches can be used, both for analysis and development of appropriate systems [29]-[40].

Related works

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At this time, the problem of demining territories and using a robot to do so is incredibly relevant. It is not surprising that many researchers are studying this issue and devoting many scientific works to it. Let's look at some of them.

The study [41] presents a comprehensive solution for autonomous underground mine rescue using aerial robots. In particular, a new class of Micro Aerial Vehicles are equipped with the ability to localize and map in subterranean settings, explore unknown mine environments on their own, and perform detection and localization of objects of interest for the purposes of mine rescue.

Authors in [42] note, that dangerous tasks such as bomb disposal, enemy territory surveillance, search and rescue can be efficiently carried out by the Military Support and Rescue Robot.

Hamza, M. F. in [43] simulates localization, navigation and mapping of vehicle undercarriage, because Detecting bomb under the car has been one of the routines for police and military personnel during their mission to protect important individual from bomb threat.

Gupta, S. S. in [44] writes that the bomb detection is basically carried out by using a human bomb squad or dogs which carries the involvement of living beings and their loss can be very costly. In order to just stop this mishap Gupta, S. S. have designed a robot that could actually defuse the bomb from a distance wirelessly as this robot will have a mechanical arm for itself which will be used for bomb diffusion using hand gesture control and will have a clipper to clip the wires as well as it is loaded with a Wi-Fi camera which is self-capable of capturing, live streaming and recording, at day as well as at night and can capture at 360 degreesin horizontal plane and 120 degrees on vertical plane which will be used for surveillance and identification purposes.

Scientists in [45] propose the robot, that detects the explosives buried in the ground or explosives lying above the ground using induction balance metal detector system.

The work [46] focuses on the design and build of a semi-autonomous, solar-powered, unmanned robotic system operating with real-time object detection function, used for various military and rescue operations such as explosives disposal, enemy territory surveillance, and search and rescue.

Hardware modules selection for a mine-searching mobile robot

The selection of hardware modules is an important stage in mine-searching mobile robot design and development. The selection process includes determining the components that will best meet the requirements of the robot's planned functions, have the appropriate technical characteristics and price. Every module, from the microcontroller to the sensors and actuators, plays a vital role in ensuring that the robot performs its tasks efficiently and reliably.

The microcontroller in the drone is critical because it integrates and processes data from the sensors, facilitates communication between the drone and the remote control, providing real-time control and monitoring. This allows you to perform complex tasks. The ESP-32-CAM was chosen, for which it is possible to choose a camera for different tasks and in different price ranges.

Having analyzed cameras for ESP32-CAM, we can conclude that the most optimal option for the project is the 2MP OV2640 with a standard 12mm loop and a viewing angle of 66°, due to the fact that the ESP-32-CAM is usually sold with this camera.

The best choice will be collectorless motors as the output devices. The choice of brushless motors is justified, due to their higher efficiency, longer service life and less need for maintenance.

This type of motor provides better performance, precise control and reliability, making them ideal for complex and continuous operations in robotics.

SunnySky X2207S was chosen as the most optimal engine option due to its adaptability to different types of power supply, the average price in relation to the design features of the engine.

Readytosky ESC 40A was chosen as a universal option of the speed regulator, due to the optimal price and adaptability to a large number of motors and to different types of batteries.

A servomotor will be used as an executive device. The main task he will solve is the maneuvering of the drone in space. The SG90 was chosen as the actuator due to its availability and widespread availability compared to other servo motor models.

The power distribution board is a necessary part of the power supply module. GEPRC GEP-XT60-PDB V1 is more desirable because of the many advantages available. It is designed to provide the highest possible performance and reliability when using a 4-layer 36mm x 50mm PCB. The PDB distributes power from LiPo batteries up to 4S and provides synchronized and regulated 5V and 12V DC outputs to power cameras, servos, receiver, flight controllers, video transmitters, LEDs, etc.

Choosing the right battery for our robot is essential to ensure optimal performance and longevity. An ideal battery provides sufficient power, has a high energy density, a long working time and the possibility of rapid recharging. In addition, it must be lightweight, safe and compatible with the robot's power requirements. The most profitable option is Fullymax 14.8V 2200mAh Li-Po 4S

A metal detector will act as a sensor. It is possible to single out the MDS-60 as desirable due to the presence of a structural mounting hole. The MDS-60 is a self-assembling metal detector. It consists of metal parts and electronic components that must be assembled according to the instructions. This metal detector allows you to detect metal objects hidden underground or in other materials. It can be used for archaeological excavations, safe detection of metal objects, etc. The device works on the principle of an electromagnetic field. When the metal detector coil moves over a metal object, it causes a change in the electromagnetic field. This change is captured by the sensor and transmitted to the microcircuit of the controller, which interprets it as a signal of the presence of metal. The search results are displayed with the help of sound and light signals, enabling the user to precisely determine the location of the metal.

The MDS-60 comes from the developer disassembled.

The set includes the following 17 components:

– 1 board;
– 1 470 Ohm resistor;
– 1 resistor of 2 kΩ;
– 1 resistor of 200 kΩ;
– 1 potentiometer for 1 kΩ;
– 2 ceramic capacitors of 0.022 μF;
– 2 ceramic capacitors of 0.1 μF;
– 1 electrolytic capacitor of 100 μF;
– 1 LED;
– 2 S9012 transistors;
– 1 transistor S9018;
– 1 switch (6-pin);
– 1 connector;

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– 1 buzzer.

All components are soldered to the board according to the basic electrical diagram shown in Fig. 1.

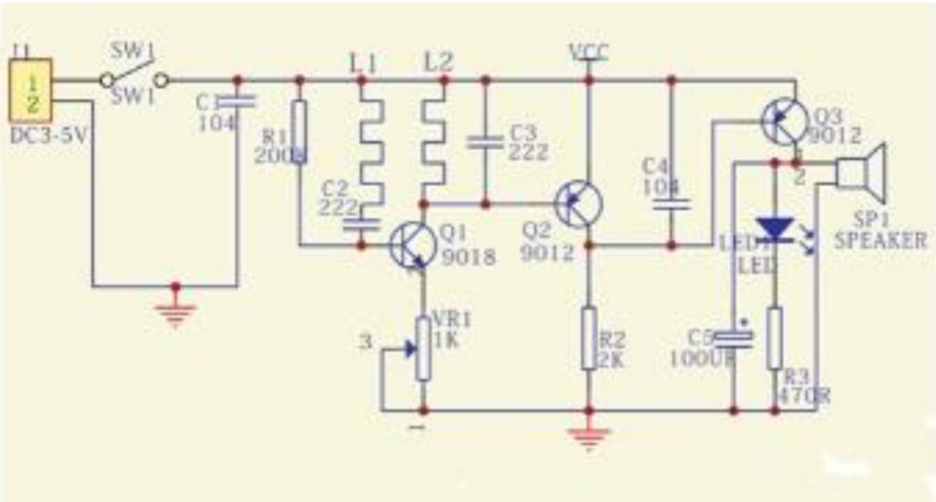

Figure 1: Electric principle scheme of the MDS-60 metal detector

In the assembled state, we get the MDS-60 metal detector, which is shown in Fig. 2.

Figure 2: Assembled metal detector MDS-60

With all the components that were selected, a connection diagram was developed, which is shown in Fig. 3.

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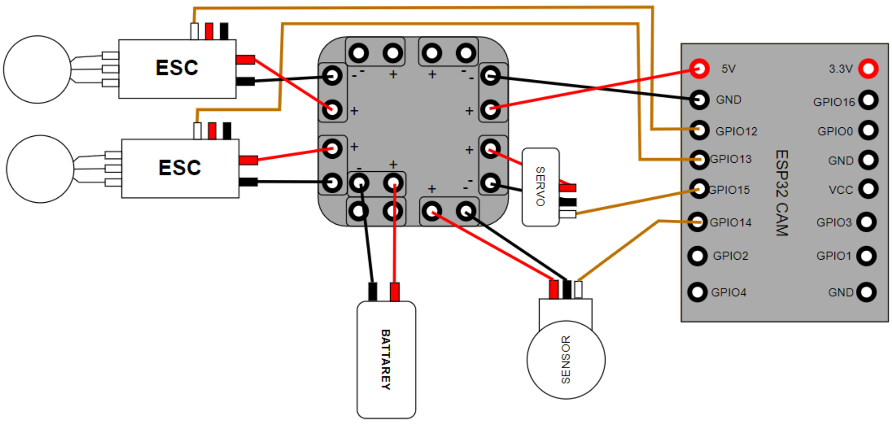

Figure 3: Connection diagram

We solder the following elements to the corresponding terminals on the power supply board: speed regulators up to 12 V of the board terminals, power supply of the servo motor, metal detector and ESP-32-CAM - to the 5 V terminals of the board, battery - to the power contacts of the board itself.

To the ESP-32-CAM, the 5 V and "ground" terminals are soldered to the corresponding terminals on the power circuit board, to pin GPIO 12 we connect the signal pin from the speed regulator, which is responsible for executive device 1, GPIO 13 - the signal pin from the speed regulator, which is responsible for executive device 2, GPIO 14 – signal output from the metal detector, GPIO 15 – signal output from the servo motor.

We connect 3 terminals from brushless motors to the corresponding terminals of speed regulators.

We insert the camera into the corresponding connector on the ESP-32-CAM board itself.

We get the result shown in Fig. 4.

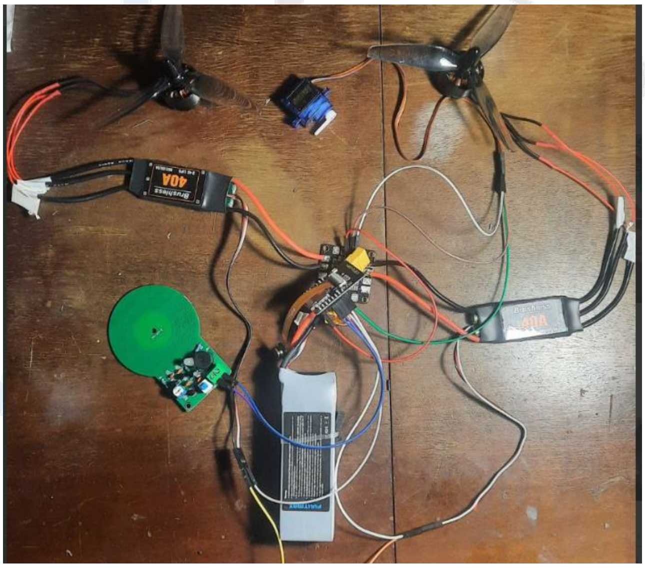

Figure 4: Assembled connection diagram

According to the instructions, the model was assembled (Fig. 5). A sweaty polyethylene bag was used as an air cushion.

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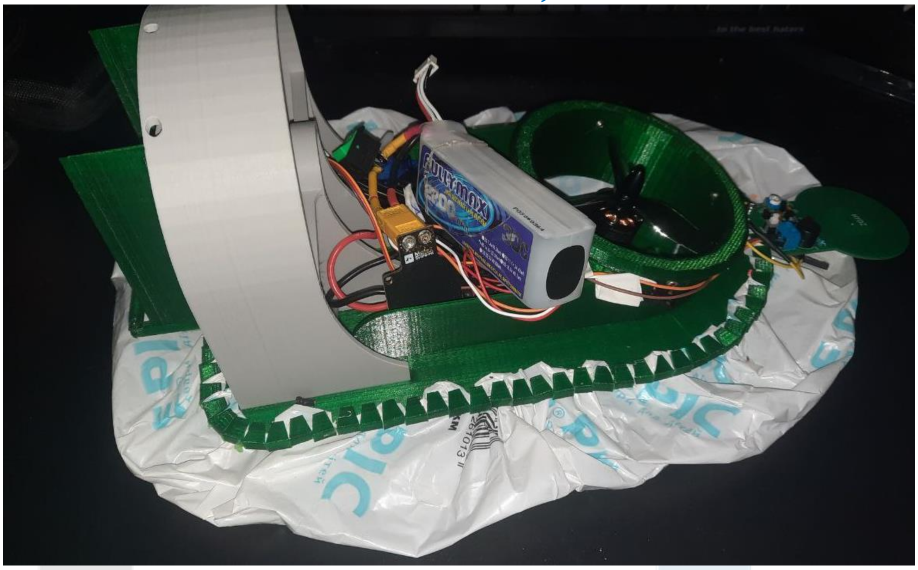

Figure 5: Assembled layout

CONCLUSION

A general structural diagram of the project was developed, which depicts the main components of the robot. An analysis of technical means was carried out, on the basis of which the most optimal technical means for the development of a mine-detecting robot on an air cushion were chosen. It was necessary to choose: a development board, a camera, a sensor, a servo motor, speed controllers and brushless motors, a power distribution board and a battery.

In the future, it is planned to develop software for this robot, as well as carry out calculations of the control dynamics of the servomotor and lighting

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