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QUADROCOPTER HARDWARE AND SOFTWARE DEVELOPMENT

Abstract. Relevance. Over time, people have come to realize the potential of drones not only in the military but also in civilian industries. Their functionality is constantly expanding, and they are becoming a key tool in various areas of society. Currently, quadcopters are used to monitor the condition of forests, detect forest fires, control the operation of pipelines or power lines, and deliver goods to hard-to-reach areas. They open up new horizons and contribute to the development of various industries, providing effective solutions for various tasks and challenges. Currently, there is a wide variety of quadcopters from different manufacturers, but the price of most is too high. **Object of research**: quadrocopter hardware and software. **The purpose of the study** is to create a fairly cheap solution using Arduino. **Research results**. Current models of drones can be varied in design - from simple to foldable, which opens up wide possibilities for expanding their functionality depending on their purpose. This study proposes to use the Arduino microcontroller to create a quadcopter. The authors describe in detail the components selected for its construction, the main stages of design and testing.. **Conclusions**. Without a pilot on board, unmanned aerial vehicles can be more efficient and cost effective than manned aircraft. This approach reduces the weight and size of drones, expands their capabilities, and provides greater autonomy in operation. In other words, unmanned aerial vehicles have the potential to improve efficiency and reduce costs compared to manned aircraft due to the absence of a person on board. Developing software and hardware for a quadcopter requires interdisciplinary knowledge in electronics, programming and aviation mechanics. Thanks to modern open platforms and availability of components, creating a quadcopter is becoming a reality not only for engineers, but also for enthusiasts. This approach opens up wide opportunities for experimentation, research and innovation in the field of unmanned aerial vehicles. Drones are an important tool that is rapidly gaining popularity and opening up new possibilities in various fields, from entertainment and scientific research to commercial applications.

Keywords: quadcopter, hardware, microcontroller, software.

Introduction

As a result of technological progress, quadcopters are becoming increasingly popular and accessible to a wide range of users [1]. Technologies for using drones in various areas of life are developing, including aerial photography, monitoring forest resources, precision farming, environmental monitoring, and search and rescue operations. It is important that the development of unmanned aerial vehicles occurs in the absence of common standards and requirements for their design. This leads to a variety of drone characteristics determined by their size, functionality, flight range, takeoff type, specialization, and other parameters. Currently, there is a wide variety of quadcopters from different manufacturers, but the price of most is too high. **The purpose of the study** is to create a fairly cheap solution using Arduino.

Without a pilot on board, unmanned aerial vehicles can be more efficient and cost effective than manned aircraft. This approach reduces the weight and size of drones, expands their capabilities, and provides greater autonomy in operation. In other words, unmanned aerial vehicles have the potential to improve efficiency and reduce costs compared to manned aircraft due to the absence of a person on board [1].

Analysis of recent research and publications. Information about software and technical means of controlling drones is in most cases presented on the websites of manufacturers, there are scientific publications that present a comparison of the characteristics of various means [2–7]. Yes, Kucherenko E.I. and I.A. Vakalyuk [8] analyzed the key components of the UAV, including autopilots, 16 hardware and software control platforms, sensors, interfaces and control systems. They compared the functionality of the platforms and found a lack of documentation on the energy consumption of the equipment.

Presentation of the main material

Current models of drones can be varied in design - from simple to foldable, which opens up wide possibilities for expanding their functionality depending on their purpose. Regardless of what internal components the drone (multicopter) uses, the main elements remain unchanged. The drone consists of such parts as a frame, a flight controller, an engine, a battery, a communication controller and sensors. These elements work efficiently to ensure stable flow, save energy and transmit data. The frame determines the shape and structure of the drone, the flight controller handles it with arms, the motors provide traction, the battery powers all systems, the communication controller ensures communication with the operator, and the sensors provide information about the environment for the drone. Autonomous Poliotu ta Vikonannya Zavdan.

This study for the quadcopter design includes an Arduino Nano 3.0 software microcontroller, an NRF24L01+PA+LNA radio frequency module, a piezoelectric beep speaker, a 3D analog stick, and the Race model's motors. Spec 2205 KV2300 and Gamefan Flash 7040 propellers for them. A Brushless 40A speed regulator controller and a self-propelled battery type 3s on 21700 Samsung 40A batteries have been installed. The equipment includes a self-propelled remote control. All these components are mounted on the frame of the Mark 4 HD model.

More details about the components:

1. Arduino Nano is a fully functional miniature device based on the Atmega328 (for Arduino Nano 3.0)

or Atmega168 (for Arduino Nano 2.x) microcontroller, specially adapted for development boards. In terms of its functionality, the device is similar to the Arduino Duemilanove, but differs in its dimensions, the variety of power connectors and the use of a different type of USB cable (Mini-B). Arduino Nano has been developed and manufactured by Gravitech [3].

2. The NRF24L01+PA+LNA droneless module with an antenna operates at a frequency of 2.4 GHz and supports transmission speeds of up to 2 Mbit/s. The radio channel on these radio modules can exchange information with the recipient directly. Radio reduction can be combined with several devices based on nRF24L01+ or NRF24LE1. The dartless module can be used at distances up to 1000 meters [9].

Batteries. As a rule, they are composed of one or more elements, such as lithium-polymer or lithium-ion batteries, and cause the shell to be wrapped in plastic or other insulating material [9].

Quadcopters often use lithium polymer (LiPo) batteries. The stench is known for its high energy density, lightness and high tension and is ideal for unmanned aircraft such as quadcopters, the fragments provide high tension with a small vase that allows the devices to sit in the wind for a long time. LiPo batteries may also be used with other types of batteries, such as Li-ion, Nickel Metal Hydride (NiMH) and others, depending on the needs of a particular quadcopter. ta yogo zastosuvan. In order to power motors with power requirements greater than 25 amperes, it was decided to create a battery based on three high-current lithium batteries Samsung INR21700 40T type 21700, as well as vikoristati BMS controller for charging.

3. Race Spec 2205 KV2300 motors are one of the popular motors that are used in many quadcopters, drones, and racing drones. They are strong, fluid and maneuverable, and are ideal for racing drones and other fixed-wing drones that require high fluidity and maneuverability.

4. Brushless 40A motor speed controller, often also called ESC (Electronic Speed Controller), is an electronic device that controls the speed of the brushless motor in quadcopters, car models, aircraft and other models. RC controls.

5. Gamefan Flash 7040 is a propeller that is widely used in quadcopters and other models with RC controls, especially in racing drones and freestyle quadcopters. According to him, the Gamefan Flash 7040 propeller is a popular choice among quadcopter pilots who are looking for high speed and efficiency in their flights, especially in racing and freestyle. Its characteristics allow you to achieve optimal results in different minds.

6. P'ezoelectric sound speaker - sometimes also called simply "p'ezodynamic" - this is a type of speaker that uses a piezoelectric effect to create sound. Piezoelectric materials, such as quartz, resonate when an electric field is applied and produce sound sounds. In contrast to traditional speakers, which rely on the electromagnetic field to control the diaphragm, piezoelectric speakers operate without magnets or mechanical parts.

7. 3D analog stick - a camera element that is ideally used in a remote control for playing quadcopters, video games, as well as for various other devices that require precision and analog keruvannya. Zagalom, 3D analogue sticks are important components for precision and analogue recording in various devices and applications. All these components (Fig. 1) were selected by us through their versatility and brightness. The Arduino communication controller itself through its versatility, openness and ease of adjustment.

Fig. 1. Components assembled for a quadcopter

The quadcopter consists of two pairs of rotors and screws, arranged around a square frame. You can perform a vertical landing and landing, similar to normal guintocryls. However, the control system between gyrocopters and quadcopters is completely differentiated from one to the other through the dynamics of the field. Vikorist is given a coordinate system as a base for the quadcopter, the motors are arranged in the "×" configuration (Fig. 2).

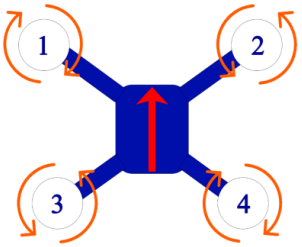

Fig. 2. Quadcopter warehouse

This means that at the tops of the square frame there are two motors that wrap around the year arrow, and two that wrap against the year arrow.

The flow of the space is ensured by the change of the end force and the moment on the skin axes. To ensure correct torque and force changes in the system, motors are installed and configured to operate in pairs, as shown in Table 1. Motors 1, 2, 3 and 4 are designated Motor 1, Motor 2, Motor 3 and Motor. 4.

For translational movement of the quadcopter, it is necessary to tilt the platform in coordination with the desired axis. The tilt angle of the quadcopter is determined by the roll, pitch and yaw conditions of movement in three dimensions (3D), as shown in Fig. 3. Based on the location of the motors described in table 1, it is necessary to simply change the speed of movement of one of the pairs of motors in order to move in space. This allows the quadcopter to move in three dimensions and control it using only four inputs.

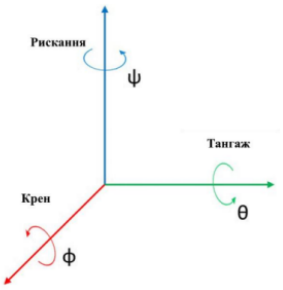

Fig. 3. Designation for movement in 3D

Table 1 – **Paired operation of engines**

	Gas				rooll				pitch				yaw			
Motors	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4

Considering the control efficiency and the need to ensure sufficient flight time, it is important to choose the right battery for the quadcopter. A 3S battery has a voltage of 11.1 V (3 cells of 3.7 V each). The task is to calculate the flight time of a quadcopter with such a battery and a known current consumption.

Input data:

- Battery capacity C=4000мАг.
- Battery voltage V=11.1В.
- Maximum current consumption I=25A.

Flight time calculation:

1. Let's convert the battery capacity into ampere-hours (Ar):

C=4000мАг/1000=4Ar.

2. Let's calculate the flight time using the battery capacity and maximum current consumption:

Flight time (hours)=C/I=4Ar/25A=0.16 hours.

3. Convert flight time into minutes:

0.16 hours ×60 minutes / hours =9,6.

So, at maximum power, the quadcopter will fly for approximately 9.6 minutes on a 3S battery with a capacity of 4000 mAh and a maximum current consumption of 25 A. First, the control system was assembled. For ease of installation, everything that was needed was placed on a breadboard, as shown in Fig. 4.

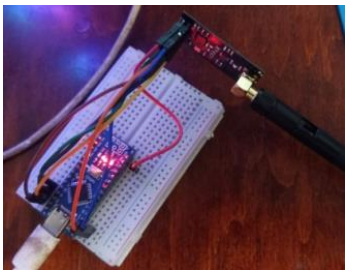

Fig. 4. Example of assembled components on a prototyping board

Next, the control panel was assembled. (Fig. 5). The microcontroller firmware was written using the Arduino integrated development environment. For the correct operation of the program and code, libraries such as Servo and nRF24L01 were used.

The appearance of the quadcopter and the remote control is shown in Fig. 6.

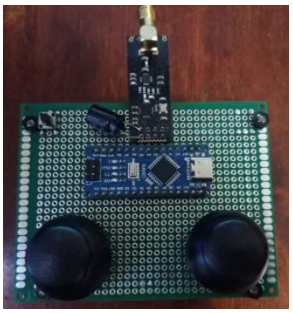

Fig. 5. Example of an assembled remote control on a prototyping board

Fig.6. Quadcopter and remote control

The final stage involved tests in a controlled environment. Flight log files were analyzed, PID parameters were adjusted, stability and response to control were checked. Changes were made to the code or hardware.

Conclusions

Drones are an important tool that is rapidly gaining popularity and opening up new possibilities in various fields, from entertainment and scientific research to commercial applications. Developing software and hardware for a quadcopter requires interdisciplinary knowledge in electronics, programming and aviation mechanics. Thanks to modern open platforms and availability of components, creating a quadcopter is becoming a reality not only for engineers, but also for enthusiasts. This approach opens up wide opportunities for experimentation, research and innovation in the field of unmanned aerial vehicles.

Конфлікт інтересів. Автори декларують, що не мають конфлікту інтересів стосовно даного дослідження, в тому числі фінансового, особистісного характеру, авторства чи іншого характеру, що міг би вплинути на дослідження та його результати, представлені в даній статті.

Використання засобів штучного інтелекту. Автори підтверджують, що не використовували технології штучного інтелекту при створенні представленої роботи.

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Розробка програмно-апаратного забезпечення квадрокоптера

В. В. Васюта, М. О. Бедрик, В. Б. Васюта

Анотація. Актуальність. З плином часу люди стали усвідомлювати потенціал безпілотних літальних апаратів не лише у військовій сфері, а й у цивільних галузях. Їх функціональні можливості постійно розширюються, і вони стають ключовим інструментом у різних сферах суспільства. Наразі квадрокоптери використовуються для моніторингу стану лісів, виявлення лісових пожеж, контролю за роботою трубопроводів або електроліній, а також для доставки товарів у важкодоступні райони. Вони відкривають нові горизонти і сприяють розвитку різних галузей, надаючи ефективні рішення для різноманітних завдань і викликів. На даний час є велике різноманіття квадрокоптерів від різних виробників, але ціна у більшості зависока. **Об'єкт дослідження**: програмно-апаратне забезпечення квадрокоптера. **Метою дослідження** є створення достатньо дешевого рішення, використовуючи Arduino. **Результати дослідження**. Сучасні моделі дронів можуть бути різними за конструкцією – від простих до складних, що відкриває широкі можливості для розширення їхнього функціоналу в залежності від призначення. В даному дослідженні для створення квадрокоптера пропонується використати програмний мікроконтролер Arduino. Автори детально описують компоненти, обрані для його побудови, основні етапи проектування та тестування. **Висновки.** В умовах відсутності пілота на борту безпілотні літальні апарати можуть бути більш ефективними та вигідними, ніж пілотовані літальні апарати. Такий підхід дозволяє зменшити вагу та габарити дронів, розширити їх можливості та забезпечити більшу автономність у роботі. Безпілотні літальні апарати мають потенціал для покращення ефективності та зниження витрат у порівнянні з пілотованими літальними апаратами завдяки відсутності людини на борту. Розробка програмно-апаратного забезпечення квадрокоптера вимагає міждисциплінарних знань в електроніці, програмуванні та авіаційній механіці. Завдяки сучасним відкритим платформам та доступності компонентів, створення власного квадрокоптера стає реальністю не лише для інженерів, а й для ентузіастів. Такий підхід відкриває широкі можливості для експериментів, досліджень та інновацій у сфері безпілотних літальних апаратів. Безпілотні апарати є важливим інструментом, який швидко набирає популярність та відкриває нові можливості у різних сферах, починаючи від розваг та наукових досліджень і закінчуючи комерційними застосуваннями.

Ключові слова: квадрокоптер, апаратне забезпечення, мікроконтролер, програмне забезпечення.