# ДОДАТОК А

Код програми main.py

```python
from modules.controller import Controller
from modules.sensors import SensorModule
from modules.ai_module import AIModule
from modules.fuzzy_module import FuzzyModule
from modules.reward import RewardModule

def main():
    """
    Головна функція запуску системи керування роботом-собакою.
    Отримує дані з сенсорів, обробляє їх штучним інтелектом,
    уточнює команду нечіткою логікою, оцінює результат та
    передає керуючі впливи контролеру приводів.
    """

    # Ініціалізація підсистем
    sensors = SensorModule()        # Сенсорний модуль
    ai = AIModule()                 # Модуль нейронної мережі / AI
    fuzzy = FuzzyModule()           # Модуль нечіткої логіки
    reward = RewardModule()         # Модуль винагороди / оптимізації

    # Центральний контролер
    controller = Controller(
        sensors=sensors,
        ai=ai,
        fuzzy=fuzzy,
        reward=reward
    )

    # Основний цикл роботи системи
    print("=== Система керування роботом-собакою запущена ===")
    controller.run()
    print("=== Завершення роботи системи ===")

if __name__ == '__main__':
    main()
```

# ДОДАТОК Б

Публікація за темою досліджень

EUROPEAN OPEN SCIENCE SPACE

Proceedings of the 2nd International Scientific and Practical Conference

# "Innovative Solutions in Science: Balancing Theory and Practice"

December 23-25, 2024
San Francisco, USA

## Collection of Scientific Papers

USA, 2024

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Collection of Scientific Papers with the Proceedings of the 2nd International Scientific and Practical Conference «Innovative Solutions in Science: Balancing Theory and Practice» (December 23-25, 2024. San Francisco, USA). European Open Science Space, 2024. 297 p.

The conference is included in the Academic Research Index ResearchBib International catalog of scientific conferences.

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# UNMANNED MULTIROTOR AERIAL VEHICLES

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**Introduction.** To date, unmanned aerial vehicles (UAV) are a booming field of engineering. UAV perform a wide range of both military and civilian tasks. In recent years, multirotor UAV (multicopters) have gained popularity due to their availability and ease of operation. Multicopters are used for cargo delivery, photography and videography, search operations, observation of natural phenomena and much more.

A quadrocopter (a type of multicopter) is a helicopter-like flying machine with four propellers.

One of the first quadrocopters (multi-rotor helicopters), which actually got off the ground and could stay in the air, was created by George Botezat and tested in 1922. The disadvantage of these machines was the complicated transmission that transferred the rotation of one motor to several propellers. The invention of the tail rotor and skew automaton put an end to these attempts. New developments began in the 1950s, but did not progress beyond prototypes.

Multicopters have received a new birth in the XXI century, already as unmanned aerial vehicles. Due to their simple design, quadrocopters are often used for various tasks.

**The design of quadcopters.** Quadrocopters (Fig. 1) have four constant pitch propellers (there is no automatic tilt control, unlike single and twin propellers). Each propeller is driven by its own motor. Half of the propellers rotate clockwise, half – counterclockwise, so the tail propeller quadrocopter does not need. Maneuver quadrocopters by changing the speed of rotation of the propellers [1]. For example:

– accelerate all screws – lifting;

– to speed up the screws on one side and slow down on the other – the movement is towards;

– accelerate the screws rotating clockwise and decelerate the screws rotating counterclockwise – rotation.

The microprocessor system translates radio control commands into engine commands. To ensure stable hovering, multicopters are necessarily equipped with three gyroscopes, which fix the roll of the device. As an auxiliary tool, sometimes, also used accelerometer, the data from which allows the processor to set absolutely horizontal position, and baro-sensor, which allows you to fix the apparatus at the desired height. Also, sonar is used for automatic landing and keeping a low altitude, as well as for obstacle avoidance.


Fig.1. Quadrocopter circuit diagram

Modern multicopters use collectorless electric motors and lithium-polymer batteries as a source of energy. This imposes certain limitations on their flight characteristics: typical mass of a multicopter is from 1 to 4 kg, with flight time from 10 to 30 min (30 – 50 min for unique single copies). The payload lifted by the models of medium-sized multicopters and payload capacity is from 500 g to 2 – 3 kg, which allows to lift a small photo or video camera into the air.

There are also quite large models of multicopters, with the number of rotors about 6-8 (hexa and octocopters), capable of lifting up to 20 – 30 kg of cargo into the air. In order to increase the payload capacity, coaxial arrangement of the rotors is used, which in the case of a hexacopter, for example, gives 12 motors and 12 propellers located in pairs on 6 carrier beams.

The flight speed of a multicopter can be from 0 (stationary hovering at a point) to 100 – 110 km/h. Battery power reserve allows some models of multicopters to fly up to 7 – 12 km, but in practice the range (maximum distance they can fly with subsequent return to the take-off point) is usually limited by line of sight (100 – 200 m with manual control) or by the range of radio control equipment and video link. At the same time, the best samples of such equipment, using radio signal power amplifiers and a system of directional antennas, are able to provide stable radio control and video link at distances up to 100 km. Thus, it is the flight time that imposes the greatest limitation on the range of multicopters.

**Basic principles of quadcopter flight.** A quadrocopter consists of several fundamental elements, without most of which stabilized flight is impossible. First, it is the flight controller, which processes all incoming information and converts it into signals for the motors. The controller accepts incoming information most often as a digital signal with pulse-width modulation. Four channels are sufficient for complete orientation in the air: throttle, yaw, pitch and roll. Some models of flight controllers also provide the possibility of using flight modes – then additional channels appear in the input signal. Also connected to the controller inputs are sensors that describe the position of the airplane in the air. Based on this data, the controller automatically makes adjustments to the output signal.

The signal is then processed in such a way as to output the appropriate voltage values proportional to the speed of each of the four screws. From the controller output, the signal, also pulse width modulated, is fed to the so-called PID controller, which controls the high power signal by feeding it directly to the motor itself.

The basic principles of flight of any technique are described by aerodynamics and quadrocopters are no exception. Three axes of rotation absolutely unambiguously set the orientation of the quadrocopter in space and the direction of its flight. And the direction of motion does not depend on the location of the quadrocopter itself in the air [2].

The three axes or angles listed above are correctly called pitch, roll and yaw (Fig. 2). Let's look at them in more detail.

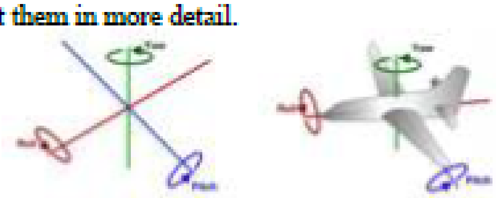

Fig.2. Euler angles – roll, pitch and yaw

Pitch refers to the rotation of the vehicle around the longitudinal axis, yaw refers to the vertical axis, and roll refers to the longitudinal axis.

If we consider a helicopter, its main rotor has an influence on pitch and roll, and the tail rotor compensates for the torque, and yaw depends on the speed at which it rotates and in what position it is in.

In the case of a quadrocopter, this is not the case. Here there are as many as four screws, two of which rotate clockwise, and the other two in the opposite direction. Accordingly, if all of the quadrocopter propellers have the same rotation speed, then all parameters will be compensated. If the rotation speed of one of the quadrocopter propellers increases, the balance is disturbed. In this case, if the speed of the propeller with the opposite direction of rotation will be proportionally reduced, the yaw will not change, but the pitch or roll will change [3].

If you increase the revolutions simultaneously on both propellers that rotate in one direction and decrease on the others, the yaw angle will be changed.

Control of the quadrocopter engines, and, consequently, the speed of rotation of its propellers, is carried out from the remote control, the signal from which is fed to the onboard computer of the quadrocopter and the necessary corrections from the gyroscope, accelerometer and so on are added to them.

**Conclusions.** When designing and building a quadrocopter, all necessary calculations should be made in order to find the optimal balance between the mass of the device, the power of the engines installed on it and a number of other factors.

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Демонстраційний матеріал

| Формат | Позиція. | ПОЗНАЧЕННЯ | НАЙМЕНУВАННЯ | Кільк. | Примітки |
|---|---|---|---|---|---|
| | | | Текстові документи | | |
| | | | | | |
| А4 | 1 | ГЮІК 041929. 014 ПЗ | Пояснювальна записка | 102 | с. |
| | | | | | |
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| | | | | | |
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