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Proposal of Coaxial-copter Control

Marek Sukop*

Department of robotics, Technical university of Kosice, Kosice, Slovakia
*Corresponding author: marek.sukop@tuke.sk

Abstract Flying robot called Flyself (concept of coaxial-copter) was based on the idea to connect the helicopter with a phone that would create the required selfie shots and instead served by selfie bar. The article describes efforts to develop the hardware part of the Flyself control and introduction to designing control algorithms.

Keywords: *coaxial-copter, robot, Flyself*

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1. Introduction

At the Department of Robotics was designed and manufactured by student a simple model of coaxial copter. It was created for the purpose of testing the behavior of such a concept flying robot. The model was designed to test basic properties during flying. Its options are limited: it is not possible to control movement along the axis x and axis y for example. The model should be possible hang in the air after perfectly balanced and it should be possible to control its height and rotation around the z axis.

2. Coaxial-copter Model

We decided to use the existing RC helicopter that we adjusted as a result (Figure 1).

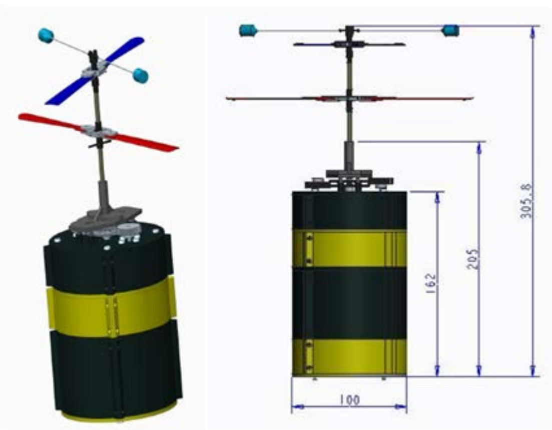

Figure 1. Coaxial-copter (Flyself) 3D and 2D model

We disassembled mechanism of helicopter and then we made a change engines, because the original engines had low rotary speed. Model was created in CAD Creo Parametric 2.0 that was used as tool for 3D printer format creator. Finally, it was made device weighing 450 grams with carrying capacity of approximately 200 grams. Expected battery life during flying with using battery is approximately 12 minutes.

3. Solution Concept of Controlling

There are too many options how to design controlling concept of coaxial-copter, but there are not many options for used model because of controlling it in axis x and y is not possible. At the Figure 2 is indicated basic concept.

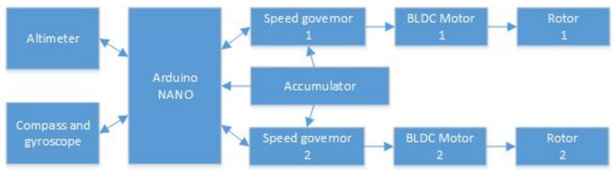

Figure 2. Basic controlling concept

In that variant it was intended to introduce Flyself with cell phone in the air and maintain a static position. Consequently, Flyself created selfie photo. Consequently, Flyself created selfie photo after which the user takes the device from the point to which the device was released. It is implemented in the device several sensors with the help of which you can maintain the necessary Flyself flight altitudes and flight rotation (three axis gyroscope, three axis magnetometer, altimeter).

4. The Component Used

It was used engine with high performance and low weight. Selected the engine type RAY C2826 / 12. This is a brushless electric motors with a rotating shell with excellent electrical properties, sophisticated design, with good cooling properties and processing quality. The efficiency of the AC motor is high (typically 0.7-0.8) in a substantially wide range of engine load. The actual power consumption depends on not only the dimensions but also on the type of screw requires a perfect optimization of the powertrain and the measurement of current, voltage, and engine speed with a propeller.

Motor specification (RAY C2826/12, Figure 3):

Revolution per volt	1350 rev/min/V
Performance	140W
Internal resistance	137mOhm
No-load current	1.2A
Max. load capacity	18A/60s

Figure 3. Motor RAY C2826/12

Suitable programmable microprocessor controller for brushless motors without sensors is constructed by taking advantage of the most advanced semiconductor technology with outstanding properties with a very simple and user friendly staff.

Basic controller functions:

- It implies extremely low internal resistance,
- It is protected against loss of control signal,
- It has a thermal overload protection: if the controller temperature exceeds 110 degrees Celsius begins to limit output power,
- adjustable voltage limit for the engine disconnected - PCO,

Figure 4. Used motor controller (RAY BEC 20A)

Battery type has been selected G3 – LC RAY Li-Pol 1600mAh/11.1 30/60C Air pack 17.8Wh (Figure 4).

Figure 5. Used battery

Technical specifications:

Capacity	1600mAh
Voltage	11.1V
Charging current	1.6-3.2A
Discharging current	41.6A
Max discharging current	80A

The control unit was designed Arduino Nano (Figure 6). The development board uses a microcontroller A Tmega 328P. Communication control unit with sensors was used I2C and SPI bus.

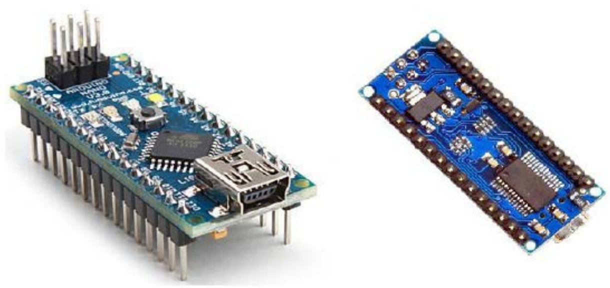

Figure 6. Control unit Arduino Nano

To watch rotation was used gyro with integrated magnetometer (Figure 7). The gyroscope is able to perceive the rotational angular velocity in the three axes within the range of +/- 250, 500, 1000, 2000 degrees / sec. It also includes programmable digital low-pass filter. Three-axis magnetometer is actually a monolithic Hall-effect magnetic sensor with magnetic concentrate. It has range measurement +/- 4800uT at 14 or 16 bits.

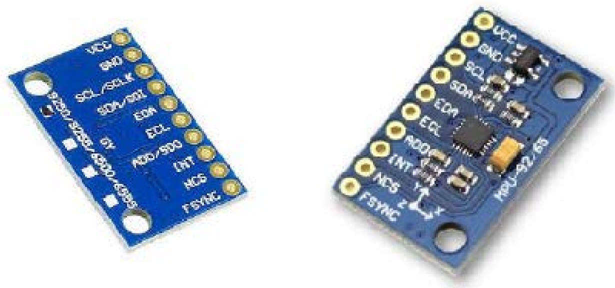

Figure 7. Used sensor shield board

To simplify tracking flight altitude has been designed ultrasonic distance sensor HC-SR04 (Figure 8). This sensor is designed to track distance Flyself to floor.

Figure 8. Ultrasonic distance meter HC-SR04

All of these components are involved in the final wiring diagram (Figure 9).

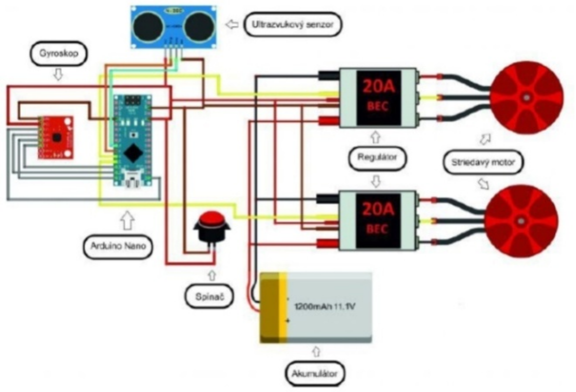

Figure 9. Wiring diagram

5. Flyself Testing

For a start it was necessary to test whether the proposed coaxial-copter is able to fly. First it was necessary to construct the type of stand (Figure 10) on which to put the test of device flying. It was suggested ropes mounting from all sides and that we can ensure that only Flyself changed its flight altitude according to the specified engine speed. In this way Flyself couldn't fly sideways with poor balance, which could be dangerous for early testing.

Figure 10. Test of device flying

The algorithm was created in the software Flowcode, which was used PWM. It was necessary to set a zero and a maximum value of PWM (123 and 247). Into the device have been added two potentiometers for testing of the ability to control the rotational speed of motors. The resulting algorithm in Figure 11.

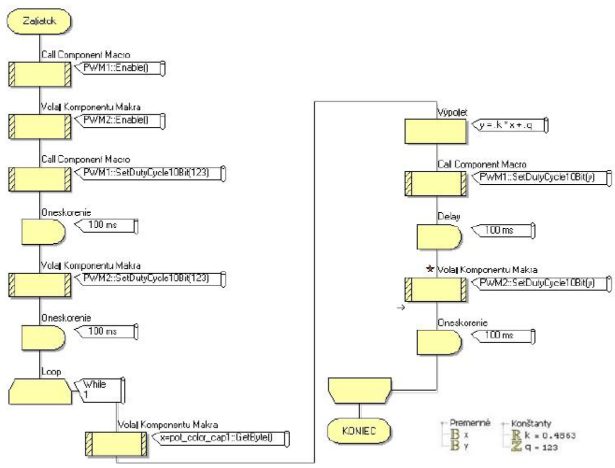

Figure 11. Control algorithm for test of device flying

At the beginning of the algorithm it is to load PWM 1 and 2, which are then set to zero. Counter changes its value depending on the rotation of the potentiometer and there is a recalculation of the value of the PWM. Using this algorithm, there is a difference-finding engine speed and at the same time their size to Flyself flew.

The next step was the setting motors speed that Flyself was able to maintain a static position (roughly) in the air without control. It was therefore written algorithm (Figure 12) in Flowcode.

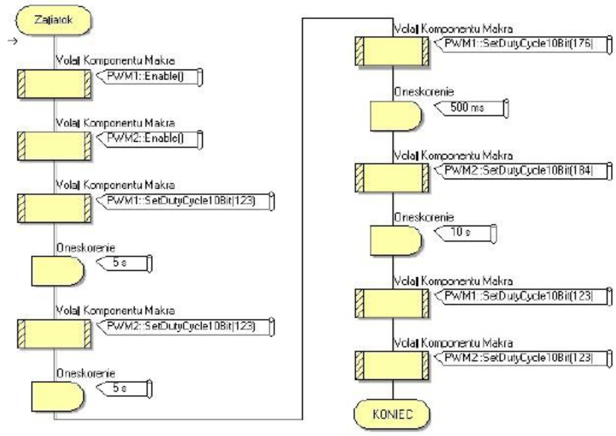

Figure 12. Control algorithm for second test of device flying

After multiple adjusting engine speed and approach procedures to be almost stable position has been selected by setting PWM motor follows PWM1=176 and PWM2 = 184. There are images of flight Flyself in these tests on the Figure 13.

Figure 13. Flyself in second test

6. Control of Stable Condition

When designing motor speed control, we started with PID speed motors control:

$$u_1(n)+u_2(n)=$$

$$K_{Pv}e_v(n)+K_{Iv}\sum_{k=0}^{n}e_v(k)+K_{Dv}\left(e_v(n)-e_v(n-1)\right)$$

$$u_1(n)-u_2(n)=$$

$$K_{pr}e_r(n)+K_{Ir}\sum_{k=0}^{n}e_r(k)+K_{Dr}\left(e_r(n)-e_r(n-1)\right)$$

Where u is the PWM value for motor *1* or *2*. In the first formula is solved height of flight and in the second formula is solved rotation Flyself around axis z.

Algorithm for stable condition control is on the Figure 14. The algorithm is repeated in an infinite loop every

60ms, which is sufficient time to cause the absorption of emitted ultrasound waves. This algorithm can be improved by using timer interrupts and external input interrupts. This would be a stabilizing the sampling interval.

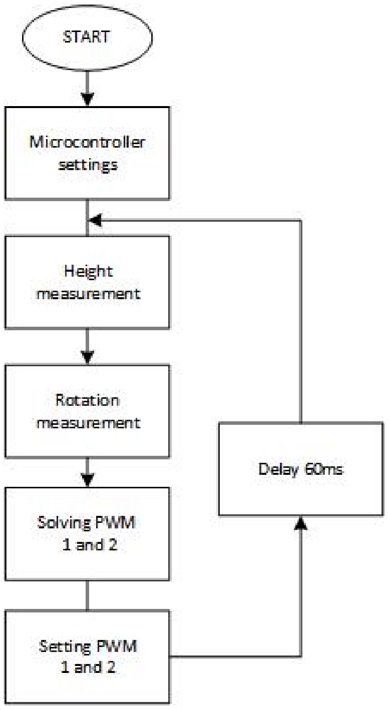

Figure 14. Algorithm of stable condition control

Acknowledgements

Selecting a controller Arduino Nano to obtain a device suitable for flight testing of Flyself. At the beginning of the implementation of the control were initially designed algorithms to test the ability of flying Flyself. At first, flyself was mounted on the ropes and was thus tested its ability to fly. Secondly, it has been tested the ability of the still hangs in the air. Both tests were successful and Flyself prototype was ready for testing other control algorithms.

In the future it would be better to add tilting ability for Flyself, because of there will be much better maneuverability. It also would have to remove the need to precisely balance the device. By supplementing other sensors would also achieve better stability. In this case is necessary to write better algorithm that is able to create better features of device flight for precision selfie pictures.

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