Development of Quadcopter for Tracking Object Using Image Processing

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Abstract. Quadcopter is an unmanned aircraft that could be used as an image recorder at various view angle that can’t be placed by a human. This research is done to planning, building and implement a quadcopter that is equipped with a camera. Then, we apply for a tracking object program in the quadcopter which is called image processing. Therefore, this research begins by designing the mechanical and electrical of the quadcopter. While the designing of the software is done by making image processing program using C++. Data collection is done by testing the device in each section. Based on the result of research and testing, the result shows that quadcopter could follow a straight moving human, then it turns 90° to right as far as 10 meters. But, there are any movements that we did not expect before, which is in the altitude of the quadcopter, it because of the instability of the loiter flight mode.

1. Introduction
A quadcopter is an unarmed aircraft that has 4 motors equipped with propellers on each motor. Its function is to produce an up force and for quadcopter movement. Moreover these main tools, some quadcopter has Global Positioning System (GPS) that use for quadcopter navigation, Inertial Measurement Unit (IMU) sensor for measuring the acceleration and movement direction orientation, an ultrasonic sensor to detect the presence of any things and other sensors that support the quadcopter performance [1][9].

Among those components, there only a few quadcopters have components that can make the quadcopter follow the movement of an object automatically. The support system that has the capability to follow the movement of an object is image processing. It has designed a quadcopter but it can’t detect and follow an object yet, because there are no camera and image processing program on that quadcopter. [2] Based on that problem, so we develop a quadcopter that can detect and follow a moving object using image processing.

2. Quadcopter and Image Processing

2.1. Quadcopter
Quadcopter is an Unmanned Aerial Vehicle (UAV) devices that are currently being researched because of its ability to take-off and landing vertically and move horizontally using only four propellers. [3]
2.2. Brushless Motor
Motor dc brushless is built by three phase with Y as the midpoint of its configuration. Y is a neutral point on the motor and a permanent magnet is positioned in front of the rotor by facing between the north and south poles. Rotation control of Brushless motor used Electronic Speed Control (ESC) which drives each phase alternately using Pulse Width Modulation (PWM). When the current through stator there will be an interaction between the electric charge and the rotor magnetic field so that the motor rotates. [4]

![Figure 1. Brushless Motor](image)

2.3. Electronic Speed Controller (ESC)
Electronic Speed Controller (ESC) is an electronic circuit that functions as a regulator of motor rotation speed on a quadcopter. This tool can also reverse the direction of motor rotation and break dynamically.

Basically, ESC Brushless creating three phase ac power, like in inverter (Variable Speed Drive) to run the brushless motor. Computer programmable speed control is generally possible with a low voltage cut-off limit, time, acceleration, braking and direction of rotation. Reversing the direction of the motor can also be done by sending three of the three leads from ESC to the motor. [5]

![Figure 2. Electronic Speed Control](image)

2.4. Flight Controller
Flight Controller (FC) is a set of several components and sensors that are used to keep the quadcopter balanced and manageable. At this time all quadcopter flight controllers have a balance sensor in the form of a gyro and an accelerometer. Some of the latest FC even have an air pressure sensor (barometer), compass (magnetometer) and GPS. The barometer sensor functions to maintain the height of the quadcopter at a certain height then the magnetometer and GPS are used to maintain orientation, autopilot, and failsave features. [6]

2.5. Wireless Audio/Video Transmitter and Receiver
Wireless audio/video transmitter and receiver are modules used to send and receive video/audio signals that sent by the transmitter and received by the receiver wirelessly. This tool uses 2.4 GHz radio waves with many channel choices. [7]
2.6. Wireless Audio/Video Transmitter and Receiver

Image Processing is a technique to process an image or bitmap which transform input images to other images for a better output quality than the input quality.[8] Analog images are divided into N rows and M columns so that those become discrete images. Crosses between certain rows and columns are called pixels. For example is an image/discrete point on line N and column M is called pixel.

3. Research Methods

The design diagram as a guide in this process of developing followers object quadcopter based image processing is to obtain a good tool in terms of quality and still consider the economic aspects.

3.1. Wireless Audio/Video Transmitter and Receiver

Design of following object quadcopter using image processing can be seen in Figure 7.
3.2. Wireless Audio/Video Transmitter and Receiver
The implementation and testing of this research are as follows:
 a. Testing of each part
 b. Combining the system form several parts to be the whole system.
 c. Tools response testing to sensor parameter
 d. Testing of the whole circuit.
 e. Testing quadcopter to follow an object as in figure 8.

Figure 6. The path of the Target Object for Experiment

4. Results and Discussion

4.1. Hardware Results
The path of voltage and data distribution can be seen in Figure 9. While the final results of the installation of quadcopter components can be seen in Figure 10.

Figure 7. Circuit of Quadcopter Components
4.2. Calculation Result of Lifting Force Quadcopter
This calculation is done by taking the lift force data of thrust brushless motor 1400-kv on the specific throttle. As for other quadcopter data as follows:
1. Thrust 40 % = 245 g, 50 % = 358 g, 60 % = 461 g, 70 % = 535 g, 80 % = 628 g, 100% = 696 g
2. Motor quantity = 4 units, Gravity (g) = 9.8 m/s² and Mass (m) = 1.6 kg
By using those data above, the lift force is obtained as in Table 1.

![Image: Circuit of Quadcopter Components Results](image)

Table 1 Calculation Data Results of Quadcopter Lift

| Thrust | Lift Force (N) | Explanation |
|--------|---------------|-------------|
| 40%    | -6.076        | Quadcopter can’t fly |
| 50%    | -1.646        | Quadcopter can’t fly |
| 60%    | 2.391         | Quadcopter can fly  |
| 70%    | 5.292         | Quadcopter can fly  |
| 80%    | 5.409         | Quadcopter can fly  |
| 100%   | 11.603        | Quadcopter can fly  |

4.3. Test Result of Arduino Nano PWM
This test aims to determine the modification of the quadcopter motion command signal. By Applying the PWD Arduino Nano Output which is connected to the Voltage output pin on the Potentiometer. The results of this test can be seen in Table 2.

Table 2 Test Result Data of Arduino PWM

| DAC Out Value of Arduino (analogWrite) | RC Signal Value Output in YAW Channel (pwm) | Quadcopter Movement |
|---------------------------------------|---------------------------------------------|---------------------|
| 140                                   | 1506                                        | Stay in Position (Mid) |
| 100                                   | 1403                                        | Turn to Left (Left)  |
| 180                                   | 1607                                        | Turn to Right (Right)|
4.4. Image Processing Test Result

![Image of tracking program using color in circle shape](image1.png) ![Image of tracking program using in any shape](image2.png)

Figure 9 Image Processing Test Result. (a) Tracking Program Using Color in circle Shape. (b) tracking Program Using in any Shape

Testing of area-based image processing program, the author did to get the mapping coordinates for the tracking system, this program is suitable for all objects, contours, and movements and colors because this program locks the shape, color, and movement of objects accurately and sends coordinates mapping results to Visual Studio which is then manipulated to move the quadcopter.

This program is better than the previous program that the authors tested because in addition to tracking objects, this program also maps the coordinates of object movements in real time, unlike the previous program which can only be tracking round objects and contrasting colors.

4.5. Quadcopter Flying Test Results Using Image Processing in Following Objects

![Image of quadcopter control screen](image3.png)

Figure 10. Display of Visual Studio Image Processing before TheQuadcopter Takeoff

Initially, HSV (Hue Saturation Value) of quadcopter camera set up so that it can detect a single clump of color as can be seen from Threshold Image, as the trial is yellow, then the X and Y coordinates appear as the image coordinates of the object.

When the program detects an object located on the right side of the screen, Arduino sends a signal of 180 analogWrite which is the same with the command to the left on Channel YAW RC. Then the quadcopter rotates on its axis to the left, but there is an additional vertical downward and horizontal downward movement which is a form of quadcopter instability when image processing is executed.
4.6. Quadcopter Flying Test Results Using Image Processing in Following Human

At this point, the object being followed is human and the color sample detected is the clothes worn by humans. Tests are carried out to find out how far the quadcopter can move when following humans with movements as shown in Figure 11.

When the quadcopter is at a height of 1.5 m, the tracking switch on the RC is changed from the manual to the automatic tracking position. Then the quadcopter rotates in place looks for the middle position of humans based on the camera. When humans move forward the quadcopter moves forward (pitch) slowly also and moves to rotate (yaw) left and right. Based on the author's observation, the quadcopter can follow human movements as in Figure 18 as far as 10 meters, after that the quadcopter maneuvered around humans because of the lack of stability in the quadcopter.
5. Conclusions

Based on the results and discussion, some conclusions can be drawn as follows:

Modifications and quadcopter assembly have been carried out. The quadcopter has been equipped with an altimeter sensor, accelerometer, GPS and camera sensor. Image processing testing to detect and follow objects using quadcopter has been carried out. The test results show that the quadcopter can follow a straight moving object and then turn around 90° as far as 10 meters. However, there are some unwanted quadcopter movements in the altitude or height of a quadcopter caused by quadcopter instability when flying in loiter mode.

References

[1] Anonyms, Droneindonesia.com. 2015. Assemble Mini Drone Quadcopter with Minimum Cost (Original in Bahasa: Merakit Mini Drone Quadcopter Dengan Biaya Minimal). http://www.droneindonesia.com/2015/02/merakit-mini-drone-quadcopter-dengan-biaya-minimal/. Accessed on 6th February 2018.

[2] LisuallodanMuh. Sirmanwan Suwardi. 2017. Designing Image Processing Object Based Drone Followers (Original in Bahasa: Rancang Bangun Drone Pengikut Obyek Berbasis Pengolahan Citra). Makassar: State Polytechnic of Ujung Pandang.

[3] Anshori, Syaifuddin. 2016. Designing Quadcopter for Optimum Route Search on Peatland Fires Using Particel Swarm Optimization Method (Original in Bahasa: Rancang Bangun Quadcopter untuk Pencarian Rute Optimum pada Kebakaran Lahan Gambut Menggunakan Metoda Particel Swarm Optimization). Universitas Islam Negeri Maulana Malik Ibrahim Malang, Indonesia.
[4] Saputra, Roni, et al. 2011. Design and Initial Testing of Brushless Dc Motor Control for Independent 4-Wheel Drive Platform Robot Rev-11 (Original ini Bahasa: Perancangan dan Pengujian Awal Kendali Motor Dc Brushless untuk Independent 4-Wheel Drive Platform Robot Rev-11) Journal of Mechatronics, Electrical Powers, and Vahicular Technology Vol. 02 No 2, pp 85-94, Bandung: LIPI.

[5] Tefay, B., et al. (2011). Design of An Integrated Electronic Speed Controller for Compact Robotic Vehicle. Proceedings of Australasian Conference on Robotics and Automation. Australia: Monash University.

[6] Anugerah, Risha. 2016. Flight Controller on Quadcopter Systems Using IMU (Inertial Measurement Unit) Based on ATmega 2560 Microcontroller (Original in Bahasa: Flight Controller pada Sistem Quadcopter Menggunakan IMU (Inertial Measurement Unit) Berbasis Mikrokontroler ATmega 2560). Yogyakarta: University of Sanata Dharma.

[7] Zilog, Inc. 2008. Electric Bike BLDC Hub Motor Control (PDF). Zilog, Inc.

[8] Hendy et al. 2011. Identifying and Tracking Objects Based on Real-Time Image Processing (Identifikasi dan Tracking Objek Berbasis Image Processing secara Real Time). Surabaya: Institut Teknologi Sepuluh Novenber.

[9] Keigo Watanabe, Kouki Tanaka, Kiyotaka Izumi, Kensaku Okamura, Rafiuddin Syam, Discontinuous Control and Backstepping Method for the Underactuated Control of VTOL Aerial Robots with Four Rotors, Intelligent Unmanned Systems: Theory and Applications Studies in Computational Intelligence Volume 192, 2009, pp 83-100