UAV Vision System for Rescue Payload Delivery

D Mardiansyah* and A H S Budi
Department of Electrical Engineering Education, Universitas Pendidikan Indonesia, Jl. Dr. Setiabudhi 207, Bandung 40154, Indonesia.

*dicky.mardiansyah8@gmail.com

Abstract. Disaster can happen anytime and anywhere. First aid should be done as soon as possible, but not all disaster locations can be accessed easily. Therefore, it needs a vehicle that can deliver a rescue payload quickly and accurately to the location that difficult to access by humans. This research aims to create a multirotor Unmanned Aerial Vehicle (UAV) that can deliver rescue payload or another payload automatically to a specific location. The multirotor type used is a hexacopter. It can carry a maximum payload of 2 Kg. The flight control (FC) used in the UAV is Pixhawk. FC used to control the UAV automatically based on the coordinate input and the specific direction. To determine the target of payload shipment, the UAV equipped with a webcam that can track the shipping target by capturing color and shape. The UAV use the raspberry pi to process the image then send instructions to the pixhawk by using Mavlink and Mavproxy communication to drop the payload in the desired place.

1. Introduction
Nowadays the use of Unmanned Aerial Vehicle (UAV) has grown rapidly. The UAV, also known as Drone used in various needs such as military, Search and Rescue (SAR), photography, agriculture, courier, and others. Autonomous flight of the UAV has attracted much research efforts during the past few years [1]. In the field of SAR that concerns on human safety is required to always standby in overcoming the disasters. Speed and accuracy are the main concern for SAR. However, some disaster locations are very difficult and risky to access by humans. U.S. Coast Guard has expressed their interest in the use of UAVs to aid its helicopter in maritime or SAR missions [2]. In addition, UAVs can increase the searching area using the onboard infrared camera, by reducing the risk of human safety with a low-cost budget.

Autonomous required many abilities such as evaluate global positions, altitudes and movements to control their stability [3]. However, autonomous systems still have some lacks, especially in position systems that only use GPS sensor [4]. Therefore it needs a system that can handle the lacks of autonomous UAVs that only use GPS sensor. One of the methods to reduce the GPS weakness is to use a computer vision system. Research about this vision system has been developed on UAV to improve that technology at this time.

Determined position system with Image-Based Visual Servoing (IBVS), which tracks certain features on the landing platform. This method depends on adaptive control rule, moreover by considering failsafe rule flight mode that currently in use is also affected. The result is satisfying, they landed with a smooth position on moving landing [5].

The research on [6] presents the determining of position system with image-based by using quadrotor equipped with facing down GoPro Camera. This UAV is using vision algorithm. Images that captured
by the UAV processed by the laptop with long-distance control, then the data is resubmitted to the onboard controller. The Laptops will give command periodically with new coordinates to the UAV so it can be landing in the right position.

This research will explain about computer vision system that will install on UAV as rescue payload sender to increase the precision of determining the payload delivering target. This system consists of Raspberry Pi 3 as a Single Board Computer (SBC) and webcam Logitech C920 Pro HD 1080p as a vision sensor that can see the bottom area of UAV. This System is using image processing technique with OpenCV library and python programming. The System will read the Hue Saturation Value (HSV) of the target that will be used as delivering target or landing target. UAV will still use GPS as coordinate determinants. However, when the UAV is on destination’s coordinate the Vision system will work and give a feedback to Flight control (FC) for going to the centre of the target.

2. Unmanned Aerial Vehicle

2.1. Design

Basically, the UAV vision system is a general drone that equipped with a vision system to add the target tracking capabilities. This is the component used in this UAV (table 1).

| Component      | Type           | Category     |
|----------------|----------------|--------------|
| Pixhawk        | 2.4.8          | Controller   |
| Raspberry Pi   | V.3            | Controller   |
| Battery Lipo   | 4S 5500 mah    | Power        |
| Telemetry      | 433 Mhz        | Communication|
| Radio Transmitter | Turnigy 9XR | Communication|
| GPS            | M8N            | Sensor       |
| Webcam         | Logitech C922  | Sensor       |
| ESC            | 40A            | Speed Control|
| Brushless Motor | DJI 920Kv    | Actuator     |
| Servo          | Towerpro mg90s | Actuator     |

This UAV as shown in figure 1 is using frame kit S550 with plastic injection module material that light enough to be combined with PBC on that main part.

![Figure 1. UAV Construction](image1.jpg)

2.2. Block Diagram

On Figure 2. It explains how the UAV vision system are connected with each part. All the components are integrated on 1 UAV.
Figure 2. Block Diagram UAV Vision System
2.3. Flowchart

Figure 3. Flowchart UAV Vision System

Figure 3 will be described as followed. First initialization, then the UAV will wait for input from the user in the form of altitude, coordinate and target colour delivery, and RC. After that, if the enter key or the take-off switch button on the RC is pressed, the UAV will autonomously take off until the altitude target is reached. If the safety switch button on the RC is pressed the UAV will be piloted manually using RC. The safety switch button is for emergency only. If the switch button is not pressed the UAV will go towards the target’s coordinate in auto-pilot mode. If the target coordinate has been reached, the UAV will detect the target colour (by using HSV). To minimize the colour noises, a minimum radius measurement is given so that the camera could detect target accurately. After detected the colour, the Raspberry will give instructions to Pixhawk through MAVlink to get to the centre point of the target. If the error < 5 (minimum point to get the centre) the UAV will go down to the specified altitude then drop the rescue payload. After that, the UAV will come back to the station and land automatically or manually.

3. Vision System
This UAV used Vision System composed of Raspberry Pi as its controller and Logitech C920 Pro HD webcam as its vision sensor. The webcam is connected to the controller through the USB port. It is faced down so that it could detect the delivery target (Figure 4).
Raspberry Pi has its limitation on data processing as it only uses a 1.2 GHz quad-core processor and 1 GB of RAM. To reduce the possibility of hanging up, the webcam resolution couldn’t be used to its fullest, only 480x480 is used.

The controller used OpenCV 2.4.8 for image processing. The method used for delivery target detection is by detecting the colour using the HSV filter. To anticipate the colour noise, size limitation is given. Image processing will provide the coordinate (x, y) position of the delivery target. But as the coordinate only use 8-bit resolution, it needs to be processed first to find the centre point and divide the image into a 4 quadrant (Figure 5) using:

\[ X = X - 125 \]  \hspace{1cm} (1)  
\[ Y = Y - 125 \]  \hspace{1cm} (2)
In addition, for more accurate target positioning the angle is required. In determining the target position angle used the formula:

$$\theta = \arctan \frac{y}{x} \quad (3)$$

From the data (x, y) and the angle obtained it will be converted into a UAV movement to get to the target delivery with accurate. In the change used formula Proportional Integral Derivative (PID). The Raspberry Pi will send instructions to the FC to make the movement in accordance with the direction of the target position. The communication used the serial port using MAVLink protocol.

4. Experimental Result
The result of determining the target using vision system can be seen in figure 6 shows that to simplify controller UAV image divided into 4 area based on quadrant which can be seen in figure 7.
Figure 7. Cartesian Coordinate

From the above result, UAV will be able to position itself according to coordinates (x, y, Θ). For example when the value obtained (x, y,) then UAV will do yaw as much as Θ.

5. Conclusion and Future Work
A UAV with a vision system will make delivering payload on a target more accurate than just using GPS to determine the destination coordinates. But in the implementation, it will take longer because it will receive feedback from the camera for precision with the target. For future research is expected to find a new algorithm to reduce camera noise, so the target will be faster.

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