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A Prototype of a Quad Rotor System for forest fire Monitoring

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Indonesia as a tropical country which also known as archipelago country have vast forest and ocean. There are several natural disaster in Indonesia, one of them is forest fire which can be happened by man-made cause as brought on by slash-and-burn culture or by natural environment cause. One solution to resolve this issue is by designing a system which can be used to monitor the forest. In this research, a fire monitoring system using visual camera in an unmanned aircraft (Unmanned Aerial Vehicle, UAV) is proposed. The method for detecting the fire is HSV filter and countour filter. The video will be process in ground station to determine whether are there any possibility fire or not. The main result of this paper is a quad rotor system that capable to autonomously navigate between way points and send video to ground station.

Keywords: Quadrotor System, Fire Tracking, OpenCV, HSV filter.

1. INTRODUCTION

Lately, environmental issues on land and forest disaster happened in Indonesia. The impact of fire that perceived human form in economic loss and environment-health problem. [1] Information system for supporting the fire fighting department was usually done by experts which analyzing data provided which by towers, manned airborne-system and satellites and estimate, by visually or from images gathered by cameras, the estimation rate of spread and height of incident flames. [2]

Merino et.al. (2010) [2] presents the implementation of aerial robots for the fire monitoring. This paper also presents an experiment result of controlled forest fires monitoring system using multiple UAV's fleet.

Unmanned Aerial Vehicle (UAV) or so-called unmanned aerial vehicle is a vehicle that has the ability to fly can operate without a pilot in the vehicle. UAV is an unmanned aerial vehicle that one operation by means of remotely controlled. UAVs can be either plane or helirotor using a navigation system independent. Basically plane, or helirotor can be considered to be aerial vehicles that can carry out missions that are useful and can be controlled remotely or automatically have the ability to fly. [3]

Some studies show that there are several methods to detect Fire like hyperspectral cameras, image intensifiers and thermal cameras thathave previously been limited in use due to cost or technology considerations are now becoming widely available and affordable[4]. Beside the fire, prior research shows that fire detection can be performed by smoke detecting in real time[5].

In this paper a research to design an automated quadrotor system using a rotary wing and forest fire monitoring system is proposed. The fire monitoring system send the video from onboard visual camera in quadrotor to ground station. The video will be process using image processing application to detect the layout of the fire point.

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2. QUAD ROTOR

A quadrotor helirotor (quadrotor) is a four equally spaced rotors helicopter. The quadcopter motion is controlled by motion controller which adjusting the angular velocities which are spun by electric motors. Because of the simple structure of a quadcopter, quadcopters are used in surveillance, search and rescue, construction inspections and several other applications.

The quadcopter formation is presented in Figure 1. The dynamics of a general X type-quad rotor which determine the angular velocities which produce by the electrical motor and as the result are torques and forces. [6]

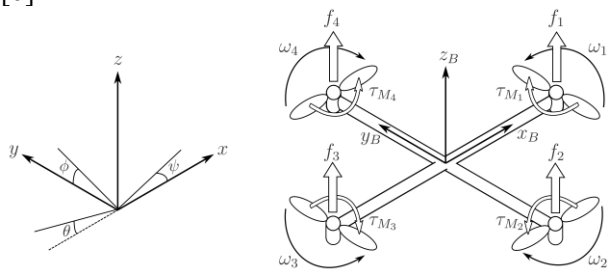

Fig. 1. The kinematic and dynamics in body frames of a quadcopter

In general, this research use the design of quadrotor frame is shown in figure 2 on the left. In general, a quadrotor consists of a center plate and four arms which used as propultion system. The main plate is usually made by several type of material. Some is use carbon fiber material, plastic and other is using aluminum plate. The material will give strength to the structure. This main plate is used to install motion control, telemetry system, sensors and baterry. The four arms are usually made of plastik or carbon fiber and they are connected to the main plate. Usually the ESC of the propultion system is installed in arm. The picture on the right of figure 2 is shown the development of hexarotor which means of six arm.

Fig. 2. Basic Quad and Hex Rotor frame Unmanned

3. AUTOPILOT

Autopilots is a function control system which provide critical functionality to control the trajectory of the platform. In the implementation of this motion controll, there are severel dedicated hardware which avalaible in the market, such as DJI, Ardupilot, PixHawk, etc. Among available autopilot implementation version, in this research, Ardupilot is choosen as one of a mature open-source project that provides reliable autopilot functionality for aerial drones. In general, the ardupilot module is shown in figure 2.

Fig. 3. Ardupilot/Arduflyer module

4. QUADROTOR SYSTEM DESIGN

With six degrees of freedom, that are three translational which drive the motion of surge, heave and sway and three rotational which drive the motion of roll, pitch and yaw, and only four independent inputs (rotor speeds to control the DC motor), a quadrotor control system is an interesting problem and are severely underactuated. In this proposed system consists of 3 parts, namely: Basic quadrotor configuration system, Camera on board system and proposed quadrotor configuration system. The general concept of the Autopilot/motion control system is shown in figure 4. In figure 5, the configuration-block diagram of the proposed camera syatem is shown. Figure 6 describe the proposed of all system.

In general, the basic quadrotor configuration consists of Sensors, microcontroller, actuators and communication module, which monitor and control the four motor. The sensors in this system are Global Positioning Sytem (GPS) sensor, compas sensor, and altitude/barometer sensor. All sensors which are mention before commonly known as Inertial Measurement Unit (IMU) Sensor.

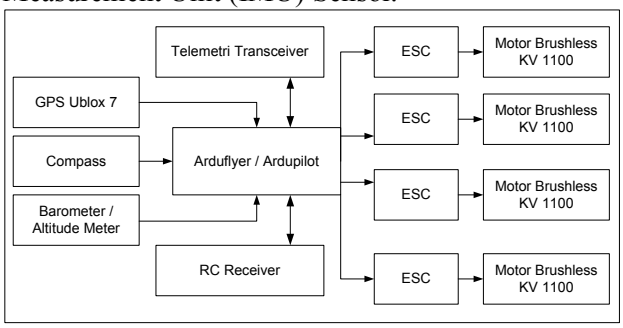

Fig. 4. Basic Quad Rotor Electronic Configuration System

The quadrotor will send the IMU data by using Telemetri Tranceiver. In this system, RC receiver function as a receiver which receive command from ground station how the quadrotor move.

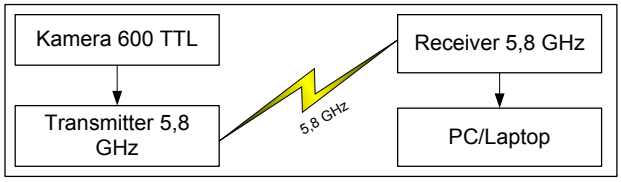

Fig. 5. Camera onboard configuration

In this paper, the configuration design of the camera on board in quadrotor consist of camera 600 TTL which will transmit the video using 5,8 GHz transmitter and the video can be seen in ground station in personal computer (PC).

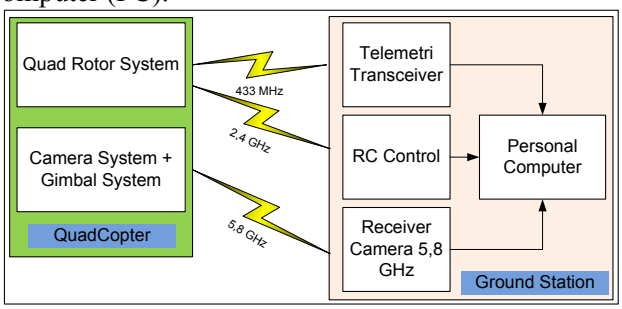

Fig. 6. Proposed Quad Rotor Configuration System

In this research, the configuration of the system proposed system is shown in figure 5. In this figure, every data and video is sent to personal computer. The personal computer will process the data and video and shown as information. The video which processed in personal computer will show wheather there is one or more firespots. In table 1, the proposed spesification for the autonomous quadrotor.

Table.1. Specification of Proposed Quadrotor System.

Part Name	Specification
Propultion System	Motor 1100 kV
Motor Driver	ESC (Electronic Speed Controller) 20A
Battery	4Cell LIPO 2200mAH
Propeller	10x4.5 CW+CCW Black Nylon
Frame	F450 Multi-Rotor Air Frame Flame White+Yellow
Flight Controller	RCTimer ArduFlyer Kit V2.5.2
GPS	Neo 7 UBlox
Camera Video Transmitter	FAT SHARK DOMINATOR V3 Camera. Max 720p
Camera Receiver	FAT SHARK DOMINATOR Goggle Receiver 5,8 GHz
Telemetri Tranceiver	3DR Radio Telemetry Kit 433Mhz Module For APM
Gimbal	Brushless FeiyuTech 3-Axis Gimbal
Dimension	45 x 45 x 20 cm (With GPS Antenna)

5. QUADROTOR AUTONOMOUS SYSTEM DESIGN

For quadrotor autonomous flight controling system, the Arduino Atmega 2560 embedded processor is used in Arduflyer 2.5.2 board. Sensor which embedded in the Arduflyer are the inertial measurement unit (IMU). IMU which consists of 3-axis accelerometer and gyroscope. The accelerometer is used to measure the Earth's acceleration vector, while gyroscope is needed to measure the rate of rotation around an axis. An external GPS, as used as position sensor, is connected to the flight controller. This external GPS is also integrated with Compas.

All sensor which integrated in the flight controller in quadrotor system is guided with an open source APM Copter firmware. In ground station, Mission Planner, an open source application from ardupilot.org, is installed. This application is enable the flight controller to flight in autonomous mode and send flight information to ground station. Figure 7 shows one example of how to configure waypoint in Mission Planner[7].

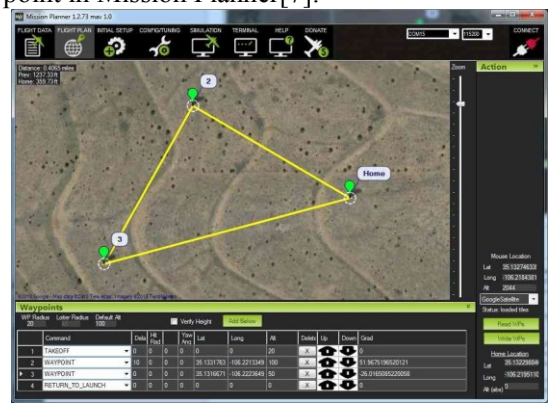

Fig. 7. Mission planner autonomous waypoint planning

6. FIRE MONITORING SYSTEM DESIGN

After the system is configured accordance to the proposed concept, figure 7 shows the flowchart used for fire monitoring. The software library that was used in this proposed fire monitoring system is OpenCV (Open Source Computer Vision Library). OpenCV is a open source library which have programming functions for a real-time computer vision. OpenCV is written in pure C ++ and several other programming language and in multiplatform operating sytem. The OpenCV library has more than 2500 optimized algorithms. The algorithm can be used to detect faces, identify objects, classify human actions in video, track camera movements, move object tracking, find similar images from image databases, augmented reality, and others. The openCV's libraries that was used in this research are HSV filter and Counter Filter[8]. In general this library is used to determine colour and shape.

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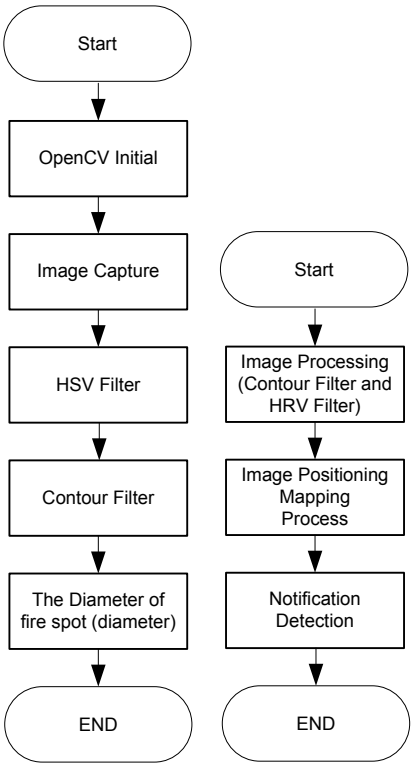


Fig. 8. Proposed fire monitoring flow chart

Figure 8 shows the flowchart for detecting fire using HSV and contour filter. After found the fire spot, the system will then mapping the fire spot position. The position algorithm for the fire spots is shown in figure 9, where every camera resolution pixel, which is reduce to 320x240 pixel, is divided into 15 segmen in horizontal and vertical pixel. If a fire is detected, then the position of the fire is showed in which segmen.

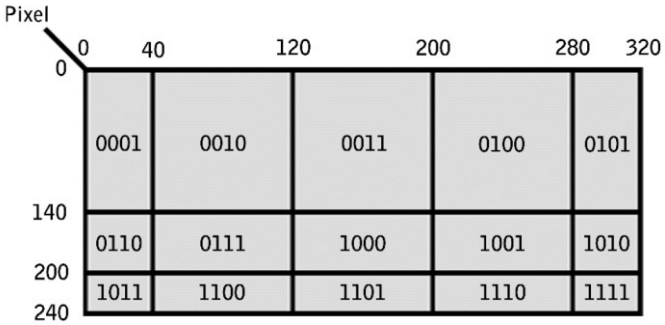


Fig. 9. Proposed fire monitoring position algorithm

Figure 10 shows the output of camera which used the process of flowchart in figure 6 and fire monitoring position algorithm. In this experiment, an orange ball is used to simulate the color of fire. The proposed system in this experiment can determine the size and track the position of the ball.

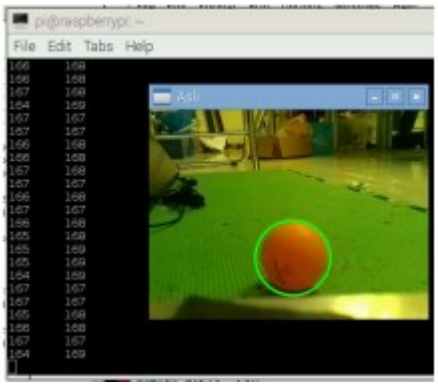


Fig. 10. Color tracking

7. RESULTS AND DISCUSSION

Figure 11 shows the quadrotor frame which used four motor and control system using ardupilot. The motors have a specification 1100 kV, which means there are 1100 rpm (rotation per minute) per volt. With this motor using 4 cell batery (approximately 14,8 volt), the quadrotor can lift its weight up to 3 kg.

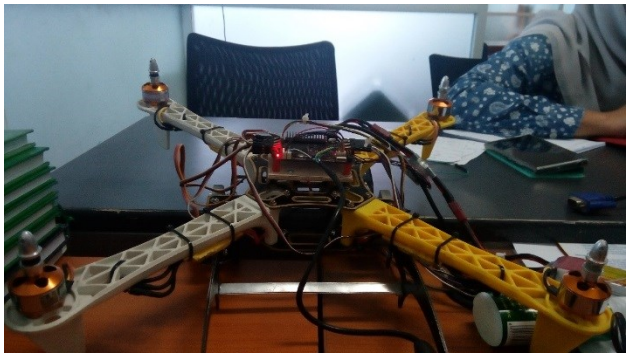
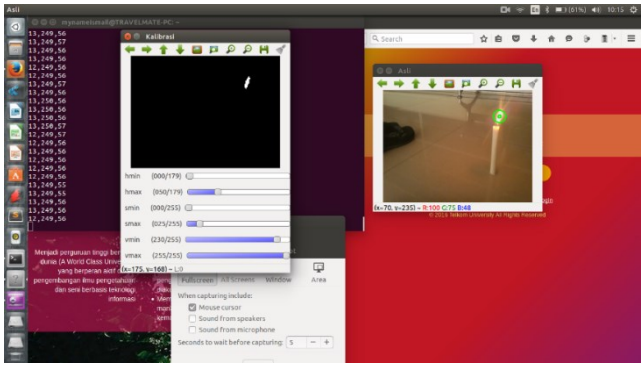


Fig. 11. Proposed Quad Rotor System

Figure 10 shows the output of camera that test a candle as the source of fire. In this experiment, in indoor environment the system can determine in several position of the candle. The problem using this algorithm in this experiment is the change of brightness can interference the ability of the camera to detect the fire. If the environment is in extra bright condition the system can not detect the fire. The experiment result is shown in table 1.



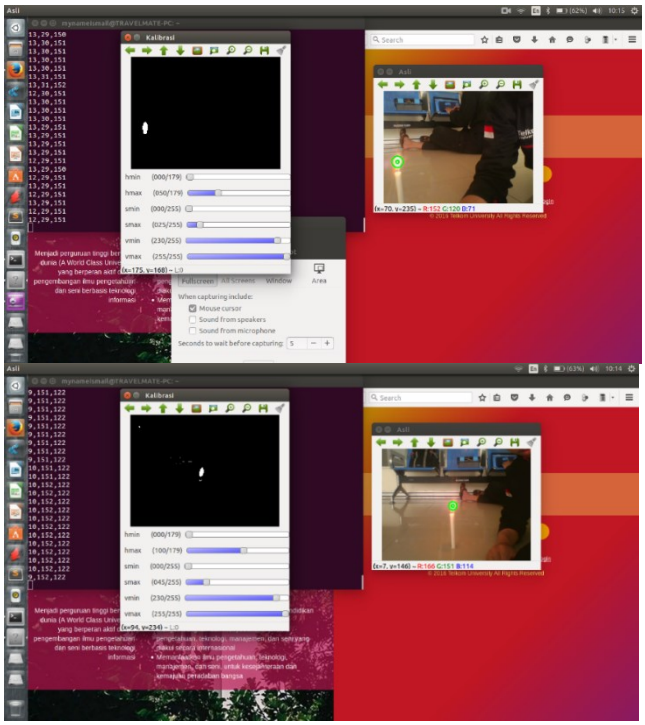


Fig. 12. Proposed fire monitoring system using a candle as fire example

Table 2. Experiment Result.

Condition	Distance	Detection	Information
Dark	1 meter	Yes	indoor
Normal	1 meter	Yes	indoor
Extra bright	1 meter	No	indoor

CONCLUSION

Fire detection system which is built in this reseach is function as in proposed system. In general, the experiment on camera system is held on indoor and it was able sending data to ground control and identified the hotspots.

Several inprovement that can be done in this system is combining IR camera to improve the accuracy and ability to detect fire.

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