UNMANNED AERIAL VEHICLES FOR PIONEER FOREST FIRE MONITORING

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Abstract. This paper presents a role of UAV (Unmanned Aerial Vehicle) in monitoring the forest fire. The Usage of UAV promises better solution than remote sensingsatellite. It promises faster, cheaper, and accurate information. Moreover, due to its application below the cloud, it brings trough to be used every time.When human does self-monitoring on forest using UAV, the fire can be prevented earlier. Self-monitoring enables a bigger monitoring. The monitoring is divided into some monitored points. When human in different position and location of the same monitored area do self-monitoring, the data got can be collected and analyzed in one central monitoring. This paper shows how the UAV gets the information of the forest situation by means of visual camera and then transmitted to the android or personal computer.

Keywords: Unmanned Aerial Vehicles**,** Flight Controller, forest fire

I. INTRODUCTION

Human needs air for the continuing of their life. They cannot live without it although only for a few minutes. Therefore, as an important substance, it has become the obligation of human to keep the quality of the air in the right manner. There are a lot of causes that can change the quality of the air, for instance: the human daily activities [1], [2], subway station [3], [4], road traffic [5], vehicles emission[6], etc.

The changing of the air quality into a bad one or always called air pollution is one of the problems faced by most of people in the world. Some scientist made an observation about the pollution effect for the health [7], [8], [9], [10], [11]. Whereas, some researchers developed many air pollution systems that can monitor the quality of the air by making improvement in the existing methods, techniques or the sensors used. Some of the researches used artificial intelligent, i.e. fuzzy logic [12], [13], wireless sensor networks [14], [15], [16], TDLS optical gas sensing device [17], etc.

This paper focuses on forest fire monitoring. Forest fire has become a big problem in Indonesia nowadays. It happened almost every year. From the article made by greenpeace.org [18], It is known that in the peat land, the fire hotspot is five times bigger than the other land. The fire forest can occur intentionally or unintentionally. For the intentionally one, the forest fire is usually done in order to open new land. It is very useful to clear the land quickly with a little cost. However, the condition of the dried peat land can spread the fire to other points. Therefore the fire can be bigger and wider. For the unintentionally, the peat land can be fired because of the contact of the dried peat land with the sun or the lightning splash [18].

The latest article published by detik.com [19] stated that on 17th of August 2016, USAModis satellite using Terra and Aqua sensor detected 482 hotspot forest and land fire in Indonesia. August till October become the peak of dry season. They become the critical period of forest and land fire. Not only in Indonesia, in 15th of August 2016, forest fire also happened in California [20]. The fire destroyed thousand of civil houses and forced them to move to the safe place. Moreover, the forest fire can cause some other difficulties. The destruction of the forest occurs quickly. Among of them are: many animals lose their places, some injuries will occur, a lot of diseases threaten, and some of the death intimidate.

The management of forest fire disaster should be planned carefully. Some difficulties arise for the solution taken. When fire fighters are deployed to the fire location, their life can be harmed. They can lose their life any time because of the high temperature of the fire, the poisonous gas occurred, or even the fire itself. When it is not planned well, they can be trapped into the thick cloud of gas caused by the forest

fire. Therefore, a system that can predict the location of the fire is really useful.

In this research, a forest fire monitoring using Unmanned Aerial Vehicle (UAV) is offered. Using UAV, an operator can monitor the condition of the fire from the other place far from the exact location. By having the information collected by the UAV, human can make a correct strategy so that the loss can be minimized. UAV provides the position of the forest fire, the latitude and also the longitude of the location using the GPS supplied on them. The situation of the fire can also be seen from the camera inserted in the UAV. Moreover, when there is no information about the fire, the UAV can be used to detect the existing smoke or heat of fire by employing the sensors implemented to UAV. Unfortunately, in this research, such sensors have not been installed yet, so the UAV can only monitor the location and situation of the fire using the GPS and camera. That's why the tittle of this paper used the word 'pioneer'. This research is the first step of the complete and complicated future forest fire monitoring.

Fig 1. Effect of forest fire in California [20]

The contribution of this paper is to give an alternative solution in controlling the forest fire. This paper intends to enlarge the consciousness of the reader that the forest fire can be prevented by self-monitoring using UAV. It is hoped that early detection of forest fire can be achieved. Early detection will lead to early rescue and it means that any losses that may be occurred can be decreased. This instrument promises faster, cheaper, and accurate information than remote sensingsatellite[21]. By self-monitoring, the forest and land condition and situation can be updated every time. The fact that it works below the cloud allows it to be used to monitor the forest every time even in the rainy seasons. By deploying some UAVs into some points of monitoring, the preservation of forest can be kept.

II. Unmanned Aerial Vehicles

Unmanned aerial vehicle (UAV) is an aircraft without a human pilot aboard. It can be operated autonomously by onboard computers or by human using remote control. There are many kinds of UAV. It can be classified based on its mode of flight, its characteristic of the task and design[22], and also its flight endurance and payload. According to the mode of flight, UAV can be divided into fixed wing unmanned aircraft, Rotor UAV, unmanned airship etc. And according to the characteristics of the design and task classification, UAVs generally include persistent type without one aircraft, tactical UAV, a miniature unmanned aircraft, pocket UAVs and so on. According to its flight endurance and payload [23], UAV can be divided into:

- High Altitude Long Endurance (HALE) UAVs, as for example the Northrop Grumman Ryan's Global Hawks (65000 ft altitude, 35 hours flight and 1900 lbs. payload).
- Medium Altitude Long Endurance (MALE) UAVs, as for example the General Atomics' Preda- tor (see Figure 2.15, left, with 27000 ft altitude, 30/40 hours flight and 450 lbs payload)
- Tactical UAVs such as the Pioneer with 15000 ft altitude, 5-6 hours flight and 25 Kg. payload

The miniature unmanned aircraft vehicle has some advantages, namely: low cost, small volume, light weight, flexible, landing with relative few restrictions, and can adapt to the complicated and changeable environment advantage[22]. Therefore, there are a lot of researchers who are interesting in it. Moreover, due to the high flexibility and strong adaptability, the miniature unmanned aircraft in the military and civilian have a wide application prospect. It also becomes the reason of using the miniature unmanned aircraft as the UAV forest fire detection[22].

UAV is also widely used for many application, for instances: electronic jamming task in military, target indication and biochemical weapons detection, the communication relay, environmental studies, natural disasters monitor and support, border patrol, agricultural survey, and large-scale ranch and forest fire detection[22].The unmanned vehicle's advantage is particularly prominent when it fights in the city. It can fly in slow speed, in order to avoid hitting buildings; it can fly to large buildings on hold for urban reconnaissance mission in the civil context[22].

Table 1. Recent Researches of UAVs application on forest monitoring

Authors	Research Scopes	References
Lan Zhang	tries software application on UAV for forest monitoring	[22]
Jian Zhang	evaluates the value of drone applications in long-term ecological studies	[26]
Rakan A.Zahawi	assesses whether remote sensing measurements from lightweight unmanned aerial vehicles (UAV) are a cost-effective substitute for tradi-tional field measures	[27]
Max Messinger	comparesSFM- and airborne Light Detection and Ranging (LiDAR).	[28]
Chi Yuan	makes a survey on technologies for automatic forest fire monitoring	[24]
Hendry Cruz	uses a novel method for detecting forest fires, through the use of a new	[29]

	color index, called the Forest Fire Detection Index (FFDI)	
Khaled A. Ghamry	investigates forest monitoring and fire detection strategies using a team of unmanned aerial vehicles (UAVs) and unmanned ground vehicles (UGVs)	[30]

UAV with computer vision based on remote sensing systems provides rapid, mobile, and low-cost alternatives for monitoring, detecting, and even fighting forest fires. The integration of UAV with remote sensing techniques useful for the execution of long-term, monotonous, and repeated tasks beyond human capabilities[24]. It also meets the critical spatial, spectral, and temporal resolution requirements, offering the potential to serve as a powerful supplement to existing methods[24]

The Global Positioning System (GPS) was developed by the Department of Defense (DoD) primarily for the U.S. military to provide precise estimates of position, velocity, and time[25]. GPS is not the first satellite navigation system. The first operational system was fielded by the U.S. Navy in 1964, and was named the Navy Navigation Satellite System [25].GPS consists of three segments: the space segment; the control segment; and the user segment. The space segment comprises the satellites and the control segment deals with the management of their operations. The user segment covers activities related to the development of GPS user equipment and services [25].

Table 1 describes some recent researches of UAVs' application that are used for forest fire monitoring. It shows that the use of UAVs are still interesting to develop.

III. Development, Testing and Measurement

The block diagram of the UAV in this research can be seen in Fig.2.

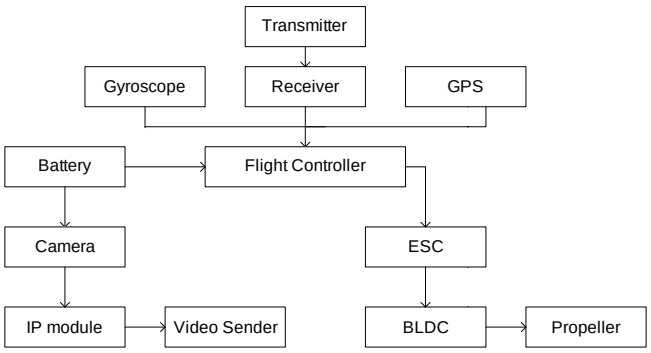

Fig. 2. Block diagram of UAV

The roles of each components in the UAV block diagramin Fig.2 can be explained as follow:

1. The battery of the UAV is used for the power. The battery used is LIPO 3 cells 220 mAh, 11.2 V. The battery used is power swithching that gives the power to the FC, GPS, and also the receiver.
2. Radio Transmitter and Radio Receiver. The UAV in this research is also used the remote controller. The remote Transmitter has function as the remote control that sends signal 2.4 GHz to the receiver .
3. Flight Controller (FC) is the main controller of the UAV. Signal received by the receiver will be processed in FC. In addition, the data from other sensor, such as gyro and accelerometer is also processed in this FC in order to achieve the balancing of the UAV.
4. Electronic Speed Controller (ESC) has function as the driver motor of Brushless DC Motor(BLDC). The PWM signal received from the FC will be transferred by the ESC to the BLDC.
5. Brushless DC Motor(BLDC) is the actuator to actuate the propeller so that the UAV can fly.
6. Camera is used to take the photograph. It uses the camera transmitter to transmit the photo to the camera receiver.
7. Global Positioning System (GPS) has function as the position controller of UAV.
8. Propellers used is propeller 5x3 Inch. There are 2 kind propellers, Clock Wise (CW) and Counter Clock Wise (CCW). CW and CCW propeller is used as pusher and puller respectively. Be careful when install these to the UAV.

The frame of the UAV and the position of each component in the UAV frame can be seen in Fig. 3 and Fig. 4. The physical shape of the UAV used in this research is showed in Fig. 5, while the flowchart of the UAV can be seen in Fig. 6

Fig. 3. QAV 250 frame [31].

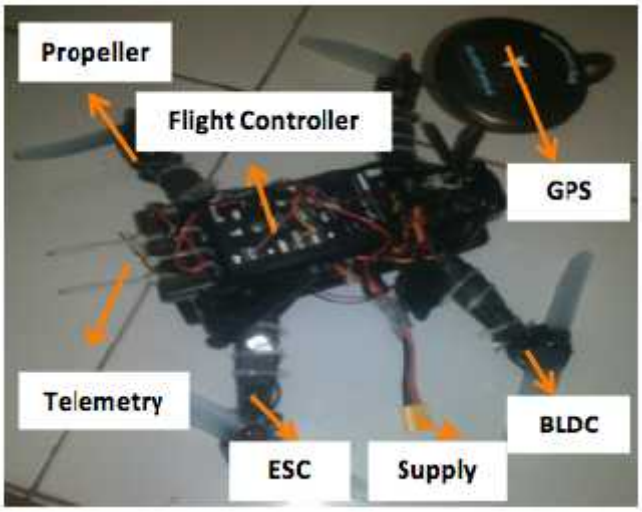

Fig. 4. The position of components in UAV

The body of the UAV uses the frame produced by Lumenier [31]. The QAV250 is a symmetric 250mm size airframe that accommodates 5" props. The 250mm is measured motor shaft to motor shaft diagonally [31]. The QAV 250 was chosen in this research because it has a small size, its performance is also great, and it is low cost frame. Moreover, it can be upgraded and it is equipped with many accessories and add ons, so that it becomes flexible and customizable. Fig. 5. shows the QAV 250 frame.

The remote transmitter sends signals that are captured by the receiver placed on board of the UAV. The receiver is connected to the flight controller. The GPS will also give the information to the flight controller about the coordinate or the information of the target location and position. In addition, the FC is also inputted the signal from the gyroscope. The flight controller then processes the data got and gives signal to the BLDC motor to move to the target position. The ESC (Electronic Speed Controller) has function to send signal to the BLDC. This ESC should be chosen properly, it should be compatible with the motors and also the battery.

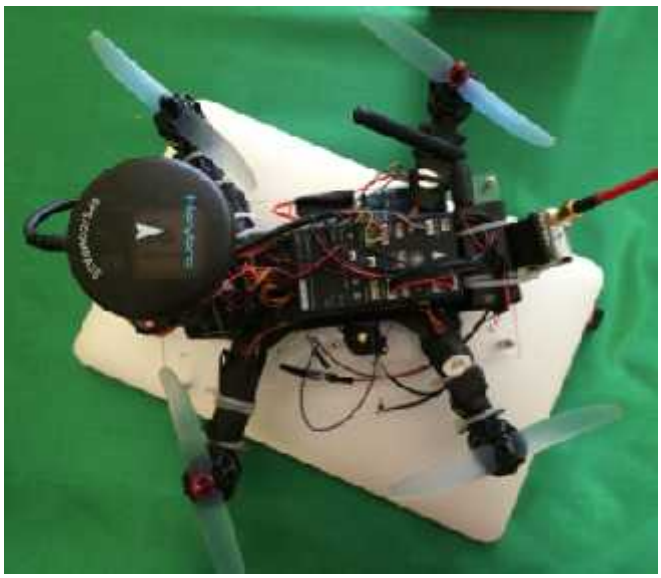

Fig. 5. Physical shape of UAV

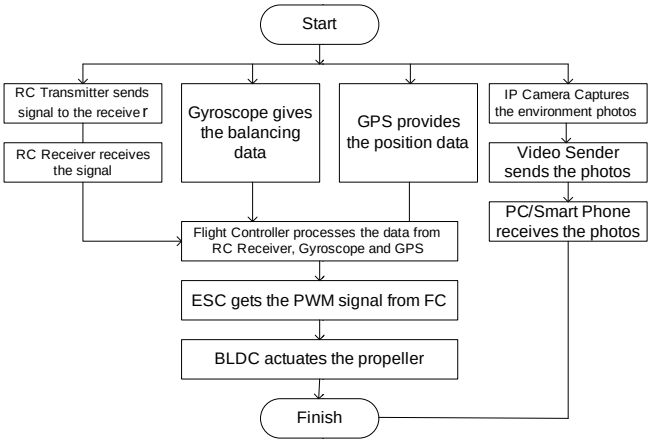

Fig. 6. Flowchart of the UAV

The display of UAV monitoring can be seen from the android. The user only needs to install the application of tower planner to its mobile phone. Fig. 7 is the data of the UAV taken from the android. The photos are taken from different height, 20 - 50 m from the surface of the sea.

Some photograps of forest monitoring taken from UAV in this research can be seen in Fig. 8. The photos were taken in different height and view.

Besides using android, the monitoring can also be displayed on PC using mission planner application. The application should be installed to the PC. The display can be seen in Fig. 9.

Fig. 8.thephotograph of the UAV from different height. (a) 20 m, (b) 30 m, (c) 40 m, and (d) 50 m.

The path of the UAV can be monitored using the PC. Fig. 9 shows the path of the UAV that it should take. The path can be arranged using the mission planner application. Once the path is set, the UAV will follow the setting way-points. Fig. 9 shows the setting path and the UAV way path respectively. The measurements of the path can be done in two modes, manual and auto pilot mode. Fig. 9 shows the UAV in manual mode take off.

From the measurement, there were some errors occurred. It can be seen from the yellow line and the purple line in Fig. 9. Yellow line is the settingpath, while the purple one is the way path of the UAV. This error happened due to some possible reasons. First, it is due to the bad weather or missed calibration of the UAV setting. Therefore, before applying the setting to this UAV, that conditions should be paid attention.

Fig. 8. (a, b, c, and d) forest fire monitoring using UAV from different side, height, and view.

Fig. 9. UAV way path in manual take off mode

IV. Proposed Work

For the future development, the UAV will be accomplished with the gas and heat sensors in order to know the concentration of the air and the predicted location of the fire. It is hoped using these sensors, the fire spot in specific area can be detected more quickly so that monitoring can be more successful. In addition, next research will focus on the UAV deployments in some points. Each point will be connected to a sensor network. When it deploys to some points in forest area, a central monitoring can be built. Thus, a real and easy monitoring can be done.

V. Conclusion

From this research, it can be concluded that the UAV provides a great promise in solving the problems of the forest fire monitoring. It can be monitored using PC or android easily. It is hoped that this research can be developed to be a perfect UAV monitoring for forest fire monitoring in the future.

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