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Research paper

Development of Drone for Search and Rescue Operation in Malaysia Flood Disaster

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Abstract

2014 drew a very terrible history to Malaysia where this country was hit by the worst flood disaster ever since for the last 20 years. This disaster has caused property lost and few death cases were also reported. Drone, new emergence technology, has the capability to be deployed for search and rescue operation in flood disaster. This technology could improve the operation of search and rescue, reduce the cost incurred and fasten the time to respond when flood happens. It is due to its capability in terms of small scale size of equipment as compared to the conventional search and rescue facilities such as boats, helicopters, etc. Therefore, this paper presents on the development of drone prototype for search and rescue operation in Malaysia flood disaster. The architecture of the software and hardware integration for search and rescue drone has been designed. The experiment was conducted to evaluate on the accuracy of flood victims' detection.

Keywords: *drone; search and rescue; flood disaster*

1. Introduction

In Malaysia, flood occurs nearly every year during the monsoon season and is considered as a regular natural disaster in the country. Given Malaysia's geographical location, we face a heavy and regular rainfall during the local tropical wet season from October to March each year and flood is a natural result of this cyclical monsoons [1]. As stated by Chan [2], when flood happens, they caused millions of Ringgit in damages, the loss of life and property along with agricultural and livestock devastation. In the case of a disaster, there is an impending need for robotic help with request to lead a powerful search and rescue operation, due to their immediate permissible deployment. Search and rescue drone has over its human partner is the relative speed at which they can enter a disaster site and start to gather data. Drone can be deployed into a disaster site very quickly because they are expendable in relation to human life [3].

Search and rescue operation to find stranded victims was carried out by boat and helicopter but this type of procedure consumed a lot of time and cost because helicopter need to fly from an airport or base to disaster zone. Moreover, search and rescue boat is difficult to be used especially to cover large area of disaster zone like in urban area. According to [4] the cost of deployment of helicopter for search and rescue mission estimates $10,000 to $15,000 per hour, manned helicopter during disaster usually operate at low attitude and bad weather, operating in this type of condition increase the risk of fatal crash that might kill the pilot and victims.

This project has two main objectives; to develop a prototype drone that can be deployed for search and rescue operation in Malaysia's flood disaster, to evaluate the proposed drone prototype through control environment experiment. As proof of concept, the project is scaled down to only control environment situation because of cost and time constraint. The proposed prototype, which consist of quadcopter, transmitter, GPS/GPRS/GSM Module V3.0 camera and receiver, is tested to find missing object within one kilometer range. The prototype will be evaluated based on response from request messages and the accuracy of the location transmitted by the module.

2. Literature Review

In Malaysian history, one of the worst flood that happened in decades is the latest enormous flooding created by the monsoonal downpour. They are the floods that hit the nation from 15 December 2014 till 3 January 2015 and brought about a sum of 210,116 individuals that have been moved in Kelantan, Terengganu, Pahang, Perak and Johor [5]. As reported in [6], at the point when the flooding happens, the victims need to be rescued from flood zone to evacuation center. Access to a few territories and evacuation center were cut off and due to the strong current and awful weather, rescue work force couldn't achieve the victims either by truck, motorboat, or helicopter. In regions like Kuala Krai and Gua Musang, adequately everybody in the district had turned into a victim because of the extent of the flooding there. The government had to conduct massive search and rescue operation over a huge territory to reach trapped victim and to provide relief.

According to news article composed by [4], Hurricane Katrina saw the first deployment of drones in a catastrophe, setting the stage for such drone deployments around the world. The hurricane was a point of interest for drone technologies, significant in their improvement for emergencies situation. The Centre for Robot-Assisted Search and Rescue (CRASAR), as part of the Florida State Emergency Response Team drone to the disaster areas that had been hit by the hurricane to discover stranded victims.

As indicated by news reported in CBC News, On April 25, a monstrous 7.8-extent magnitude earthquake tore through the capital of Nepal. Highways, streets, and trails have been wiped from the landscape, making it impossible for rescuer's vehicles to explore the territory. Drone had been used to gather information and mapping off the destruction from air because a ground survey take a long time to carry out and particularly hard to navigate in the harsh terrain of the Himalayas, while fast moving drone can cover as much as 5 to 10 square kilometers in less than hour at a high resolution [7].

As reported by The Washington Post, a group from the Federal Aviation Administration (FAA) deploy a drone along the Blanco River, Texas to help search and recovery efforts after extreme storm that killed no less than 17. Chief Engineer at the Texas University brought a group of eight people and four drones to disaster zone. The drone's camera provided live video footage, which streamed on a monitor at the operation center [8].

2.1 Impact of Drone Application toward Search and Rescue Operation

With increasing events of natural disasters recently, the development of drone to be used in search and rescue operations has turned out to be more important. The main advantage that a search and rescue drone has over its human partner is the relative speed at which they can enter a disaster site and start to find for survivals. Drone can be deployed into a catastrophe site very quickly because less risk compare to human live [3]. Drone can also give situational awareness over a huge area quickly, lessening the time and the number of searchers required to find and rescue an injured or lost person, greatly reducing the expense and risks of search and rescue missions. According to [9], drone is designed to provide cost efficient, real time data and imaging, day or night, in harsh conditions and without danger to work force.

2.2 Drone Technology

Drone is a term that refers to any vehicle that can work on surfaces or air without a man on board to control it [10]. They can have different size, shape, structure, speed, and an entire host of different properties depending on their functionality.

Table 1 shows the comparative study between quadcopter, hexacopter, and octocopter. Based on the comparison, quadcopter technology is chosen to be implemented in this project because it has longer flying duration and great maneuverability.

Table 1. Comparative Study on Quadcopter, Hexacopter, and Octocopter [11]

Area of Differences	Quadcopter	Hexacopter	Octocopter
Number of Propellers	4	6	8
Advantages	Cheap to build and repair	Greater power and speed	Very fast, agile and stable.
Disadvantages	Less powerful engine	High price, Larger in size	Very expensive

2.3 Global Positioning System (GPS) / GSM Tracker Device

Working based on existing GSM network and GPS satellites, this device can be located and monitor any remote targets by SMS or call. In this project, after a drone successfully find a victim, the drone's pilot will notify about the finding to the rescuer and they will locate this device by sending a message and the device will reply the exact location. During the process, the drone will hover around the victim until the rescuers receive the location of the victim through a GSM network. This device is chosen in this project because it was very reliable during disaster, it only need slightest signal of GSM network to send and receive SMS. Come up small size and lightweight, this device can be easily mounted into a drone without affecting the drone's motor and camera function.

2.4 Searching Pattern by Drone

As stated by [12], searching technique is very important since drone have limited duration of flight time and sensor limitation. Search and Rescue team cannot deploy the drone without a proper plan. First of all, task force need to determine the optimal area where the drone effort should be deployed, which is an area where the victim is most likely to be found. Next, they have to divide searching area into appropriate sub-areas for assignment to individual search patterns. Then, select specific search patterns and their orientations to optimally cover each sub-area.

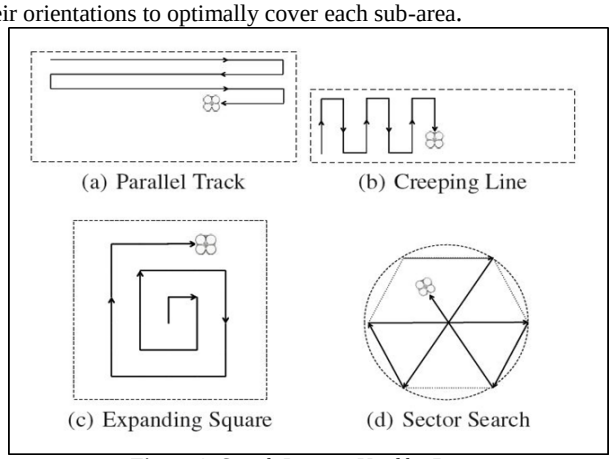

Figure 1: Search Patterns Used by Drone

3. Methodology

The applied method involves a process that comprises of seven sections that begins with literature review, problem definition, research flow, system model, system architecture, prototype development and end with prototype testing.

3.1 Research Flow

The research flow signifies that there are three main stages involved in this procedures. The first stage focuses on capability of the drone to carry device such as camera and Global Positioning System (GPS) / GSM Tracker Device without affecting the drone's mechanical function. Stage 2 allowed the drone operator to control the drone from a base station using FPV" First Person View" while searching for victims. Last stage, the tracker device will transmit location of victim to the rescuer through GSM network.

3.2 System Model

Before proposing a suitable architecture for this system, necessary software and hardware components needs to be gathered and analysed for better interpretation of the project. System model is created to demonstrate the relationship between the hardware and software components embedded in the system. The interaction between each component is briefly explained in Figure 2.

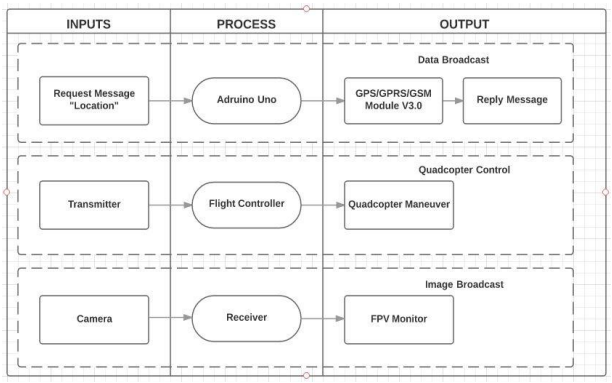

Figure 2: System Model for Search and Rescue Drone

3.3 System Architecture

As illustrated in Figure 3, the transmitter and flight controller enable the operator to maneuver the drone from range up to 3 kilometers using FPV" First Person View", a live video feed from a mounted camera on the drone. To track the drone location, device tracker will be attached to the drone. If the victim is spotted during the flight time, operator will inform a rescuer team about the finding through a radio. Data gathered from GPS module will be sent to a microcontroller that will process the data. The processed data will be sent to a Global System for Mobile (GSM) modem in the form of SMS. The rescuer team will receive a location of the victim by GSM network through SMS from the tracker device. Thus, rescuer need to request the data from GSM Module by sending SMS.

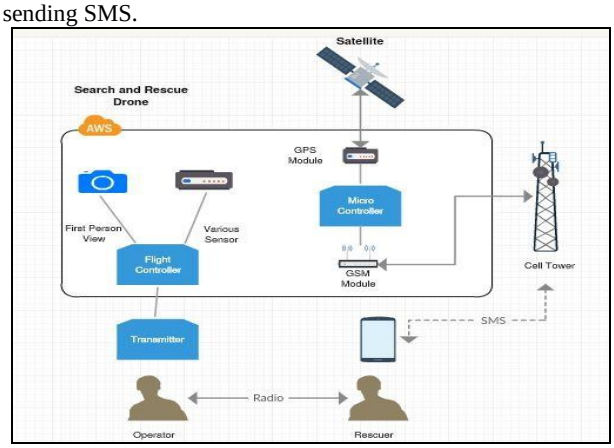

Figure 3: System Architecture of Search and Rescue Drone

4. Experimental Result

4.1 Experimental Setup

The prototype model of search and rescue drone is developed and as proof of concept, it is tested through control environment in open field. The prototype model is made up of a medium size quadcopter, transmitter, mobile phone, Arduino UNO R3, camera and GPS/GPRS/GSM Module V3.0.

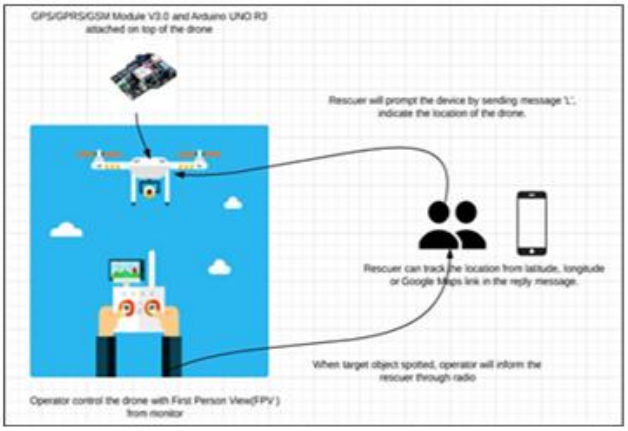

Figure 4. Illustration of Experiment

4.2 Accuracy Testing

The purpose of conducting this test is to determine the accuracy of data collected from the GPS module. In this context, data refers to the latitude and longitude retrieve from the module in degrees. The accuracy of data collected from the GPS module is determined by comparing its data with latitude and longitude that retrieved from mobile phone's GPS, the data from mobile phone are very reliable because mobile phone is using high accuracy's GPS. Tests are executed in an outdoor environment with 10 random locations.

Table 2: Result of Accuracy Testing

Location	Latitude and Longitude Retrieve From GPS Module (Degrees)		Latitude and Longitude Retrieve From Mobile Phone (Degrees)		Difference (metres)
	Latitude	Longitude	Latitude	Longitude	
Location A	4.38791	100.96338	4.38790	100.96330	9
Location B	4.38979	100.96651	4.38989	100.96646	8
Location C	4.38791	100.96566	4.38799	100.96552	17
Location D	4.38787	100.97061	4.38796	100.97049	15
Location E	4.38560	100.97263	4.38560	100.97268	7
Location F	4.38080	100.96901	4.38080	100.96889	13
Location G	4.38688	100.96269	4.38677	100.96279	17
Location H	4.38007	100.96187	4.38012	100.96182	8
Location J	4.38246	100.97693	4.38236	100.97680	1
Location I	4.38478	100.97617	4.38474	100.97612	7

4.3 Performance Testing

The purpose of conducting this test is to check the reliability of the search and rescue drone system. This is done to ensure the system can perform well in receiving the request message as well as sending the reply to the rescuer and to make sure module attached at the top of quadcopter does not impact how it fly.
Test is executed in an outdoor environment with GPS/GPRS/GSM Module V3.0 and Arduino UNO R3 attached on top of quadcopter. The quadcopter will hold the same position and altitude while receive and reply the messages. The reliability of the system is measured by comparing the number of request message sent and number of reply message received. Number of messages received will be compared with Output that indicate message had been send at serial monitor.
During the test, out of 20 trials, some of the trials need more than one request message to reply the location of victim. This may happen due to GSM module fail to receive the request message or

other factor that effects the performance of GPS module. Result of the 20 trials is summarized in a line graph shown in Figure 5.

Figure 5: Result of Trials

5. Conclusion

The two main objectives of the project have been successfully met. Development of search and rescue was a success even with some flaw. However in real situation implementation, more study and experiment need to be done. Drone technology have huge potential to be incorporated into search and rescue team, not only during disaster but also other searching mission because it can gather image and data over a huge area quickly, lessening the time and the number of rescuers required to find and rescue a lost person, greatly reducing the expense and risks of the missions. This project has great potential to be extended encompassing much functionality. Therefore, several recommendations need to be highlighted for those who are interested to continue this project: (1) autonomous flight, (2) implement more effective communication line.

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