Real-Time Monitoring Wildlife Using Autopilot Quadcopter and Wi-fi Facilities

Autopilot Quadcopter

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Abstract— From the THE STAR newspaper 14th April 2015, at least five of Malaysia's mammal species, including the dugong and the Malayan tiger are now facing extinction [1]. This is due to many causes like human activities such as logging, over-development and poaching [1]. In Malaysia, there are no advance systems or method that can monitor the wildlife more efficient and effectively. The problem of current methods like survey on footprint and direct observation, there are no technologies on wildlife monitoring system that can visually monitor during real-time on illegal activities in remote locations [3]. On top of that, the information need to be informed quickly when illegal incidents occurred in the forest so that the relevant authorities can be assigned to stop the illegal activity. This project is a real-time monitoring wildlife which uses an autopilot quadcopter and provides WIFI facility for the forest rangers or to the jungle trekkers. The design implementation that are carried out is by applying Monitoring tools using high definition camera with WIFI supported and night vision capable and Global Positioning System(GPS). The system is capable to improve the monitoring work in the jungle and also improves care control on wildlife effectively.

Keywords: animal extinction, real-time monitoring wildlife, illegal activities, WI-FI facilities, autopilot quadcopter, Global positioning system

I. INTRODUCTION *(HEADING 1)*

Data from the World Bank showed that 70 of Malaysia's 336 mammal species were threatened as of 2014, the seventh highest in the world in this category [2]. In South-East Asia, Malaysia is second only to Indonesia, which has 184 endangered mammal species, making it the number one in the world [3]. Although the World Bank does not say why, it is presumed that many mammals worldwide are dying out due to human activities such as logging, over-development, and wildlife trafficking and poaching [3]. Other than that, tropical trees typically show a broad and continuous range in adult size, with maximum height of co-occurring species ranging about 0-70m.[7] This range in statue result in a tradeoff between size at first reproduction and lifelong reproductive output, where the latter is enhanced by prolong the vegetative growth to construct large, elevate crowns that intercept much light and produce large seed crops.[7] There are a many methods that can be do for monitoring wildlife that had be used in various countries. Firstly, rangers need to spend hours in the field recording data about wild animals.[2] Secondly, UAV like aircraft are used in some parks to count large mammals.[2] Thirdly, use radio-telemetry, that is the radios attached to individual animals, can be used to

track animal movements, determine home range size and offer information on habitat use.[2] But the disadvantage of all this method is the forest ranger need to self-collect of each of the data on each camera. Walking along transect will gives an extremely challenging of the forest ranger to collect the data.

The objective of this project is to monitor the wildlife in the forest from any poacher's person that hunting extinction animal for their own satisfies. Secondly, provide a WI-FI facilities in the forest by using Wi-Fi router that brought by two quadcopters. To overcome problems that have been stated above, this project proposes a real-time monitoring wildlife by using smart quadcopter and Wi-Fi facilities, as one of the efforts to help reducing the threat of extinction of wildlife in rainforest.

The original of the project are shown below, the quadcopter that can do a real-time monitoring in range about 5km perimeter area of the forest by using two quadcopter that mounted with high definition IP camera with night vision included. Instead of monitoring by using a high definition view, GPS shield connected with Beagle bone black also used to locate the location of quadcopter automatically with data received continuously. The autopilot quadcopter controlled by using two ways. First ways is controlled remotely by an operator or the users and second ways is can be controlled automatically via pre-programmed flight path. To do a flight path, mission planner as in figure 1.3.1 by using personal computer and droid planner by using 3DR telemetry radio as in figure 1.1 below:

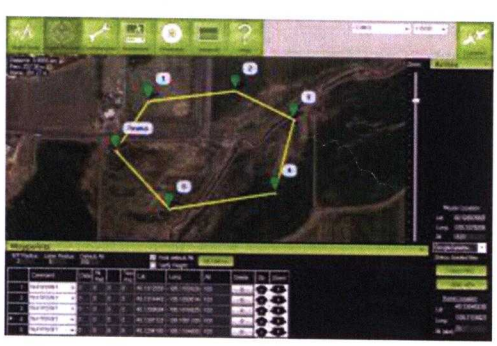

Figure 1: Mission Planner

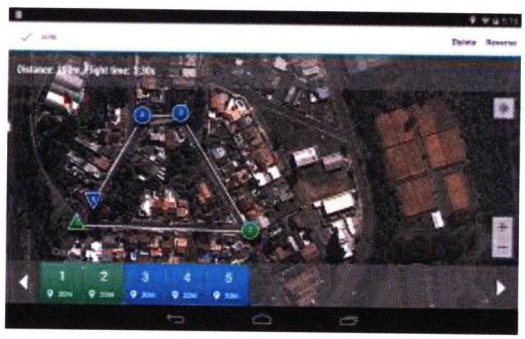

Figure 1.1: Droid planner

Mission planner is used by connecting USB cable from flight controller to the personal computer to draw the flight path of the quadcopter. Mission planner is a free, open source and it also compatible with APM2.6. The second method used is droid planner software that is to do a flight path of the quadcopter by connecting 3DR radio telemetry that connects with the smartphone. The data sending are wirelessly with a 915MH radio frequency. The quadcopter is equipped with a Wi-Fi router that can transmit an internet for the use of high definition IP camera and also for the enforcement law staffs that are assigned to monitor. In this project, two quadcopters will be used. To make the data from high definition IP camera flow to the central control, the data from second quadcopter will be send to the first quadcopter and the data from first quadcopter will direct display on the screen of Personal computer or laptop that are control by the enforcement law staffs. Instead of send a real time data to the enforcement law, the Wi-Fi router also provides Wi-Fi facility in the jungle. As we know, there are no line services that can be reachable while in the jungle. So with this project, the jungle trekker can access to the Wi-Fi facilities while the quadcopter on the top. To get the best WI-FI coverage signal from this quadcopter, the height will be set 100 meter from the surface of forest that the quadcopter can fly. The reason why two quadcopter are being used is to make a monitoring on wildlife more broad. Other than

that, the range of the WI-FI coverage also can be broad twice by connected two WI-FI router which brought by quadcopters as illustrated from the figure 1.2.

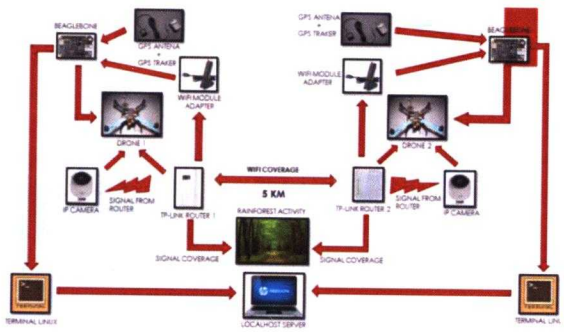

Figure 1.2: The pictogram of the project concept

In this project, the Motorola Solutions M-WiCom Platform of Beagle bone black [4] will be used as to sending GPS data that connected with GPS shield and WI-FI dongle to give out an exact location of the both quadcopter. Then the WI-FI router are used to give a WI-FI connection not only to the quadcopter, also gives a WI-FI facilities in the forest. As a main design challenge to monitor wildlife, a high definition IP camera with night vision access will be attached to the quadcopter as a main to monitor a real-time view of the activity wildlife in the forest. To view the situation in the forest in a real time, IP address from the HD IP camera accessed by using smartphone or laptop by an apps.

II. DESIGN METHODOLOGY

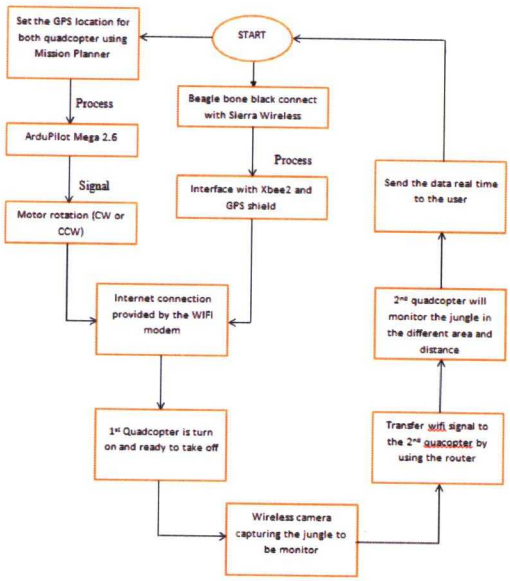

Figure 2: Flow chart of the system project

This project is divided into the following scopes: internet connection of the Wi-Fi connection router to another Wi-Fi router, designation of the autopilot by using the apm2.6 flight controller, connection internet used for high definition IP camera and GPS data sending from Beagle bone black as a server to database created by phpmyadmin. Motorola Solutions M-WiCom Beagle bone black used as a server GPS that connected with GPS shield and the data of GPS will be sending through server and display in the browser.

The first production of this project is designation of the quadcopter that capable to do an autopilot by using waypoint method in Mission Planner software as a navigation system that provides location and time information in all conditions, anywhere based on the receiver and transmitter range of the radio telemetry. By using the Beaglebone Back connected with GPS module, the GPS data flow is come from GPS module and sends it to the Beagle bone black then send it to the database and display the data by using website with localhost as an admin. To illustrate the position of the autopilot, software Mission

Planner will be used to allow setting up of autonomous waypoint.

The first quadcopter will take off automatically using droid planner with all the setting of the internet connection, beagle bone can give out data location and the IP camera successfully connected. It will travel at the distance 5km for the center depending on the power of the battery. The GPS system will track the positioning of the quadcopter as it travel far away from the user as long internet connection still connecting. Next, the high definition IP camera can do either capture the image or make live video of the situation and monitoring session will be take part. The WIFI connection with IP camera on the quadcopter sends the data from IP camera to the enforcement law.

In order to increase the area to be monitoring, we decided to use two quadcopter with the same functionality that will cover another 5km area of the jungle. At this section the first quadcopter will be the router for the second quadcopter in order to supply the internet connection. The estimation time for both processes to take place is half an hour process as one quadcopter only capable to operate only 15 minutes depend on the battery power.

II.I Quadcopter Assembly

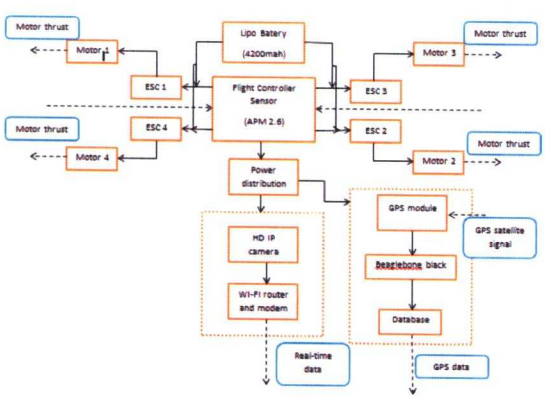

Figure 2.1: Quadcopter assembly flowchart

After deciding to create the Quadcopter, decision had been made on what electronics to use and which sensors we would incorporate into it. [5] After a lot of research on the web, found that a couple forums that discussed open source electronic and software components suitable for making a Quadcopter.[6] System design aim to build a quadcopter to lifting force that is double its own weight. This quadcopter used to lifting 2kg weight of components that attached on the quadcopter. One of the components mount on the quadcopter is HD IP camera which would be able to produce a high resolution image with its own transmitter. The camera connected with the WI-FI router that also mount on the quadcopter as to give an internet in surrounding area with 50-100 meter transmit range of internet reception. It can access for everyone that are in area 50-100 meter of the quadcopter in the jungle. This quadcopter also equipped with a features global positioning system (GPS) using Beagle bone black and GPS module. The systems of this GPS beginning with beagle bone black that act as a server allows the GPS module that produce location data to the database. Then the result of GPS location data showed using website that we create using PHP.

II.I.I Quadcopter Controller

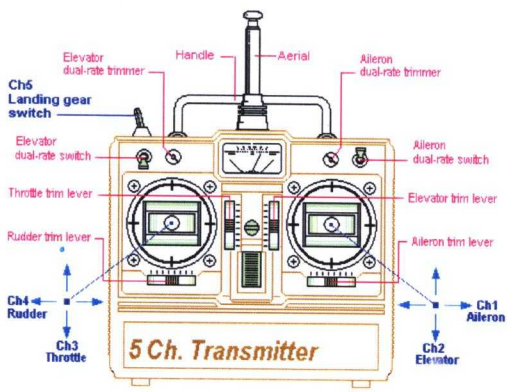

Figure 2.2: digital transmitter controller for quadcopter

Figure 2.3: 3dr radio telemetry

The designation of this quadcopter is capable to do an automatic controlled via pre-programmed flight path and manually controlled by an operator. I am using this component as to attempt an autopilot quadcopter goal in our objectives. To do a telemetry link, used 3dr radio telemetry that the transmitter of the 3dr radio telemetry attached at the laptop or smartphone that had downloaded droid planner software. Droid planner or mission planner is software that had features to make a flight path of the quadcopter and do an automatic flight from the ground instead of using digital transmitter and receiver radio. Second option of quadcopter flight is by manually controlled by an operator. In this project, we used FlySky 2.4GHz 6 Channel Digital Transmitter and Receiver Radio System.

II.I.II Mission Tab

Figure 2.4: Mission plan

The mission tab is one of the most important parts of this program. It is here a user will be able to see the current position of the Quadcopter on a map and also plan out a mission. The user will accomplish this by using waypoints which will be translated into GPS coordinates which will be sent to the APM2.6 board. Upon the start of the mission, the Quadcopter will go to the desired waypoint and complete a task that has been scheduled for that particular point. When complete, if there are more waypoints, the quadcopter will move on to those or finally come back to the base station.

III. RESULT

This result is measured based on the distance fly upwards in different height and fly left and right in a fixed 100 meter upwards and 50 meter to the right and left from the fixed height with just temporary hold altitude. The time taken for the quadcopter reached in each distance measured in seconds by using stop watch. Then for the battery usage, used a rechargeable LIPO battery that can show the battery usage. The quadcopter need to landing first to take measurement and then continue with other distance. The measurement of battery usage taken we calculate from full charge battery minus with last distance reached.

Distance fly (m)	Time (s)	Battery usage (%)
5m(up)	2	3
15(up)	3	5
30(up)	5	8
40(up)	7	10
50(up)	9	12
70(up)	12	15
100(up)	16	19
50(left)	20	23
50(right)	20	23

*total battery voltage when full charge (16.8V)

Table 3.1

Chart below shows battery usage with a distance fly for the quadcopter. Overall, it can be seen that the rises in battery usage with an increases on distance fly of the quadcopter. The factor influence for this chart result is of course the weight of the quadcopter. We are using about 2 kg weight of quadcopter. For the more weight load need to lift on quadcopter, the usage of the battery also will increased. Other than that, the type of motor used also influenced the battery usage.

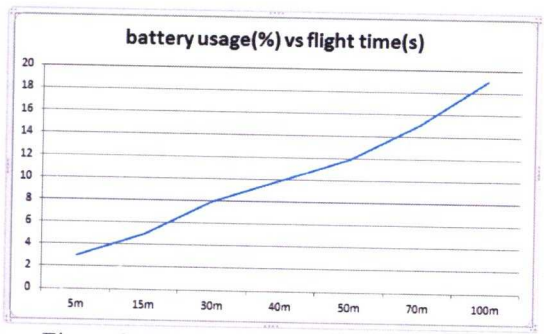

Figure 3: Result of battery usage (%) vs distance flies (m)

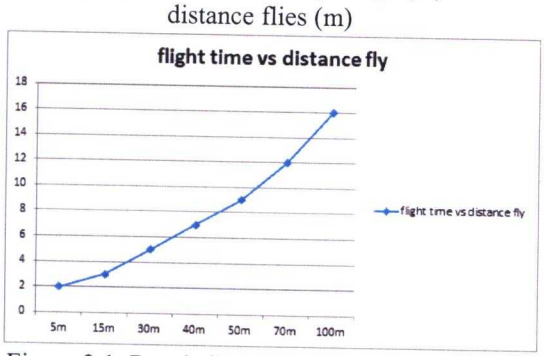

Figure 3.1: Result flight time(s) vs distance fly (m)

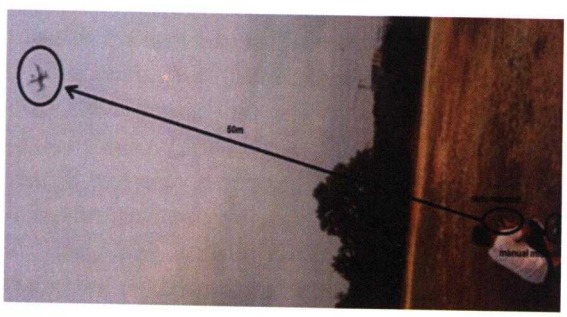

Figure 3.2: Testing flying on 50m upwards

Figure 3.3: Testing image on 50m upwards

IV. DISCUSSION

From this project, the main is creating of autopilot quadcopter is cheaper than the quadcopter sell in the market and also many functions added like do a monitoring wildlife in the jungle from any poachers and also give a free WI-FI access in the jungle. With the frame with a width of 500cm, it needed a brushless motor and propellers as a part of the components of quadcopter. I am using Tarot 2214/920Kv brushless motor because of it have an advantage on it is lack of brushes and physical commutator. This means that there is much less part that can wear out or break and need to be replaced than in a brushed motor. A brushless motor tend to be more reliable, last longer, more efficient and have life expectancy of over 10,000 hours. Other than that, we need to lift 2kg load mount on the quadcopter. Based on the calculation below that required thrust per motor, we believe that this quadcopter capable to lift 2kg weight.

Required Thrust per motor = (Weight x 2) / 4

For the calculation, based on Tarot 2214/920kV brushless motor draws 1A current on no load to produce 100g thrust(based on formula above), our quadcopter need to lift 2000g, each motor need to produce 500g each of thrust in order to hover. Then my quadcopter average ampere draw is 20Amps which is come from 20Amps = 4 motor*500g /100g.

As for needed choosing type of motor for the

quadcopter, type of battery also need to choose suitable battery based type of motor and time flying.[5] It is because, as the battery gets larger as an example, the increase in flight time becomes ineffective. Eventually it will reach a point where it just does not gain any more flight time with bigger battery.[5] This mainly caused by the weight of the battery. Other than that, the mathematical technique also needs to be done. One of them is define the Max current draw from the battery mainly to supply enough current for the motors to operate when with load. The mathematical equation can be used as below.

Max current = capacity * c-rating(from battery)

So based on the Lipo battery type with capacity 4200mah, quadcopter flight times can be calculated as below.

Quadcopter flight time = (4200/1000mah)*80% / 20 amps*60minutes = 10.08 minutes.

Obviously this quadcopter battery calculation is a very simplistic calculation base on steady hover. Based on the result that had we get, we can conclude that the usage of battery consumption in Volt is almost significance with the calculation that had we done based on the battery capacity and flight time in second of our quadcopter. Based on the result also, the time taken for the quadcopter to reach 100 meters up is 20 seconds, so to monitoring from the top of jungle can be done almost 9-8 minutes for each take off from the ground.

Although we have encountered many difficulties during this project, we have fixed most of them. Based on the title of our project that is real-time monitoring wildlife using an autopilot quadcopter and WI-FI facility, what I am doing is an autopilot quadcopter. I had faced many big difficulties that I need to encounter. One of the problems that come is having random power failures throughout the entire quadcopter. This problem makes me worried because it could have meant that one of the components on the main boards had failed which would be very expensive to fix. After do a recheck on entire components power supply, I finally discovered it was a loose connection on a power distribution board that just needed to be re-soldered. I delighted to discover this simple fix and fortunate that there were no damage components. With the power distribution problem solved, I began to try to communicate with the Quadcopter from an RC controller radio. Initially, there are some troubles getting our radio to communicate with the Quadcopter correctly. First, throttle was set in the reverse direction so pushing up on the throttle would mean that the motors would power down. This problem was easy to fix because the radio provided a polarity switch for this purpose. Then comes another problem with the motors not spinning up until the throttle was advanced 2/3 of the way. This offset meant that only a tiny movement in the throttle would have a big effect on the motor speed. This also meant that when the motors started, they started very fast and the helicopter would jump into the air without any control. I am able to remedy this problem also through control settings on the radio where we were able to scale the throttle. I had to set the minimum throttle to about 45% and the max throttle to 100%. This gave a lot larger range of throttle which allowed for a more controlled take off and better control of the Quadcopter.

V. CONCLUSION

From our research on past monitoring system that had been used, mostly the monitoring system they used is more to monitor from the camera that are attached at the tree. Unfortunately for this method, there are many drawbacks that need to consider such as the current equipment used is not fit for purpose since the camera units cannot provide near-live reporting and as they are not concealable, they are often stolen. Other than that, budget constraints are a further challenge for that method.

For our improvement design on the wildlife monitoring system, we successfully design using an autopilot quadcopter compare install the camera that attached at the tree that need the forest rangers to walking along transect into the deep forest that can be extremely challenging and dangerous. Our autopilot quadcopter can view more broad instead of view from camera that are attached at the tree. So that, any activities at range 5km area can be view from the apps that we installed on the smartphone. Apart from that, we also successfully design our project provides WI-FI facility that can be access in the forest. It is never done in Malaysia before this.

The advantage of our project compared to other wildlife monitoring system that had be used is the time consumption of forest rangers can be reduced on observing the animal in the forest. Other than that, from our project, it is more effective way on to reduce the extinction of the wildlife in the forest.

For the recommendation that can be applied on this project in the future, the flight controller of APM2.6 can be replaced with Beagle bone black which is the beagle bone is much cheaper than APM2.6. Other than that, this project also can be improved by using thermal camera instead of using high definition IP camera. By using thermal camera, the monitoring can apply not only on the animal, but also can monitor human that do an illegal activities in the jungle. Last but not least, this project can be improve by using more strengthen WI-FI signal that can give out more broad WIFI coverage that can cover almost 5km radius of area.

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