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Unmanned Aerial Vehicle Network for Remote Estimation & Supply Drop in Flooded Areas

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Abstract - *Natural disasters and calamities cause the most damage at global level, with floods being one of the major contributors. Considering this, flood mapping and damage estimation are very important for the population and authorities. This paper proposes a network of long- range drone to drone communication, image processing & supply chain to tackle this problem. A multi-level system withtwo components – Terrestrial & Aerial is proposedas support for image acquisition & signal processing from a delimited region. The terrestrial component consists of a Ground Control Station, as a coordinator at a distance, which communicates through the use of nRF24L01 single chip radio transceiver for data acquisition & communication. The aerial component contains multiple fixed type UAVs. In order to evaluate flood damage, two aspects need to be considered - area surveillance & image processing. These aspects can be accomplished by using FPV Cameras & relays specially designed to be on drones and to increase the efficiency & range. The flight controlling system used is ArduPilot for monitoring & controlling the unmanned system.*

***Key Words*: UAV, image processing, ArduPilot, long-range communication, supply drop**

1. INTRODUCTION

In recent years, Unmanned Aerial Vehicle (UAVs) with various on-board sensors have grown to be cost-effective tools for large scale aerial mapping. The suitability of a particular UAV for mapping a use-case is dependent on the required mapping extent, geometric accuracy, flight time, control distance & the payload capacity. This paper proposes the use of a **network of UAVs** as a platform for evaluation of flooded areas (especially in rural zones) with the aid of relatively cheap solution based on **image processing**. The embedded single board computer used is a Raspberry Pi connected to **FPV cameras & FPV relays** to provide an imaging system and to relay the video information further from drone – drone – GCS respectively. Moreover, an Infrared camera is connected to locate the survivors using their body heat. We use an ArduPilot Flight Controller. Using input from the sensors, the Raspberry Pi and the flight controller are able to actuate devices such as ESCs, servos, and other peripherals. A **Ground Control Station (GCS)** allows user to set-up, configure, test and tune the vehicle. For the software, we use Mission Planner, which is a full-featured GCS software supported by ArduPilot. Mission Planner offers point-and-click interaction with the hardware, custom scripting and simulation. A network of UAVs can handle the Flood Mapping & supply drop tasks in a much better manner than a single UAV. This is because multiple UAVs can be sent in different directions simultaneously to map different locations using images. These images will be passed onto GCS and then merged together to create an overall map of the affected area. With the help of two drones, a single drone can **fly twice the distance from GCS** than what the conventional range allows. This is achieved by **relaying the control commands** from the first drone to the second and so on. Similarly, images can be relayed from drone to drone up to the GCS, covering a much bigger area. Drones will also continuously transmit their **location information**. This way, if drones come in the vicinity of each other, they can take measures to avoid a collision. With the help of multiple drones attached with an IR camera, survivors can be located with the help of their body heat in the form of **infrared radiation**, thereby giving a huge edge over conventional cameras. Payload distributions can be managed by identifying locations which require a specific kind of payload and accordingly appropriate drone selections can be done based on the requirements. For instance, if a UAV carrying food discovers a location requiring blankets, then that particular location can be sent to the nearest blanket carrying drone which can then supply the required payload. Additionally, the requirements of all the locations can be sent to GCS, which can then create a list for the next supply round.

2. WORKFLOW

This section presents a detailed analysis of the System Architecture, the workflow of Monitoring Floods & locating survivors, establishing real-time communication between the UAVs and further with the GCS and explaining the supply drop process.

2.1 SYSTEM ARCHITECTURE & OVERVIEW

The purpose of the UAV system is to monitor floods, locate survivors & provide necessary supplies. To achieve this, our proposed system consist of –

Raspberry Pi:

The Raspberry Pi is an embedded computer board that runs Linux. It also provides a set of GPIO pins allowing you to interface electronic components for IoT projects. It has two USB ports and an Ethernet Port. The latest version of Raspberry Pi consists of 40 GPIO Pins, a Broadcom BCM2711, Quad-core Cortex-A72 64-bit SOC running at 1.5GHz. The new VideoCore 6 GPU allows to drive dual 4Kp30 displays and can handle H.265 decode at 4Kp60.

ArduPilot Flight Controller:

Flight Controller is the brain of the UAV. ArduPilot is an open-source autopilot system consisting of a three axis camera control and stabilization, shutter control, live video link along with a programmable on-screen-display. With the addition of advanced failsafe options, it can assist in the event of lost control signal, low battery conditions and other system failures. The GCS software supporting it is the Mission Planner GCS. It offers custom scripting, simulation and point-and-click interaction with the hardware.

Battery (LiPo):

LiPo batteries are used as a standard to supply power to the UAV motors. The battery should be able to give out enough current for 4 BLDC motors and the other components (a little more than 80-100 amps). This is calculated using the C rating and the battery capacity. A higher rating LiPo battery with approximate rating of 3S 6000 mAh 20 C provides an extended life. The 3S denotes the 3 cells of LiPo connected in series, having a voltage of 12V. The maximum current drawn from this battery (for example) is 6000*20 = 120,000 mA = 120 A. Although, for our purpose, the capacity should be enough to give the drone a flight time of at least 10-15 minutes. Keeping this in mind, a battery of higher capacity or an array of multiple batteries must be used.

FPV System:

The FPV system consists of an FPV camera mounted on the drone to capture real time video. These cameras are typically used in racing drones but their usage can be extended to surveying purposes, too. The latency of FPV camera is typically 100ms-200ms. A CCDFPV camera is suitable for this system. The system also includes an FPV relay to pass on video information from another drone.

Brushless BC Motors:

Brushless DC (BLDC) Motors are standard motors used in UAVs as they spin at a much faster rate and consume relatively less power. The higher the KV rating of the motor, the faster it spins at a constant voltage. For this proposed system, 1400KV BLDC motors are used, giving an RPM of 15,540 (1400 x 11.1V). Depending on the load, typically a BLDC motor on a UAV may draw about 20-25 amperes of current. Keeping this in mind, a battery of sufficient capacity must be chosen.

Propellers:

Propellers are lift-generating components of multi-rotor UAVs, which create lift from their mechanical motion. Higher KV motors turn the propeller quicker with less torque, while lower KV motors create high torque with low speeds. Therefore, to maintain a balance between RPM and torque, we choose a 10 inches propeller.

UAV Frame/Chassis:

The size of the frame is chosen on the basis of the size of the propellers and the total weight and volume of all the components including the payload. The material used for frames is Carbon Fiber, since it is vibration absorbent and lightweight while still being considerably rigid. For this system, the appropriate frame size would be >= 350mm.

Electronic Speed Controller (ESC):

The ESCs control the speed of the motor and act as an interface between the system and the motors. ESC provide the necessary power signals to the motors in accordance to the control signal given to them from the system. Each BLDC motor is connected to an ESC, therefore, for our quadcopter system we use 4 ESCs. The ESCs are connected to the battery through a wiring harness. A higher input voltage allows the ESC to supply more power to the motor.

NRF Transceiver:

To establish communication among the UAVs and the Ground Control Station, an nRF24 Transceiver is attached to the Raspberry Pi. It operates in the 2.4 GHz ISM band, with support for data rates of 250kbps, 1Mbps and 2Mbps and has an operating voltage of 1.9V-3.6V.

Pi Noir Infrared Camera:

The Pi Noir camera is useful for collecting data in infra-red region of the EM spectrum. With the help of a Pi Noir Infrared camera module, survivors can be easily located using their infrared radiation (body heat).

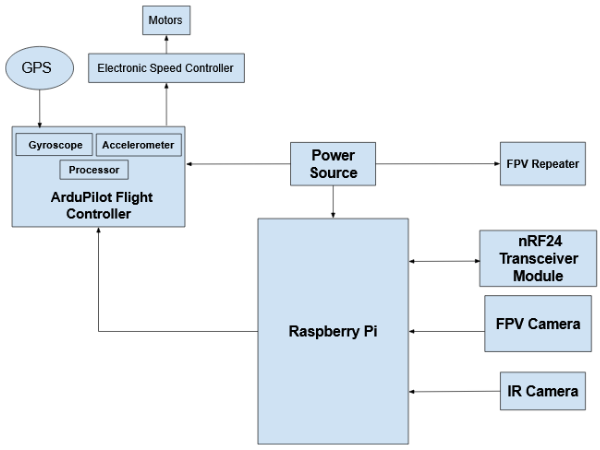


Fig -1. Block Diagram of the UAV system

2.2 FLOOD MONITORING & LOCATING SURVIVORS

In order to monitor floods, the images are obtained by means of a dual camera system – FPV Cameras & IR camera. The FPV camera used in our system is a CCD camera capable of capturing high-quality images at high resolutions. CCD camera use global shutter to capture the entire image at the same time. In the proposed system, the multiple UAVs are sent in different directions to map different locations of the area simultaneously using the images captured from FPV Camera. These images are then sent to the GCS which creates an overall map using all the images for the rescue mission. In order to capture a detailed image, a higher TVL resolution camera is used. Since, FPV cameras work on analogue video, the horizontal resolution is measured using TV lines. Using a multi-UAV system will allow us to map farther locations and monitor a larger area. This is achieved by passing control commands from one drone to other. This method increases the effective range linearly (best case) as the number of UAVs increase. Also using multiple UAVs, multiple houses and buildings are spanned simultaneously to locate survivors. With the help of Pi Noir IR Camera V2, survivors can be located by detecting the body heat in the form of infra-red radiations further easing the process. The software part consists of the **Mission Planner GCS** supported by ArduPilot. The GCS operator designs a flight path covering the search area and consequently sends commands to UAV to conduct the mission. **Fig - 2** shows the main **"Heads-Up Display (HUD)"** view of the Mission Planner Control Station. The map shows the current position of the flight simulator. Using the point-and-click mission control in real time, we can instruct the UAV to fly at a particular location. Additionally, we can choose to add custom imagery instead of Google Maps in certain cases. The images taken by the UAV will help to get a bird's eye view of the flood struck area and to locate survivor so that rescue missions can be planned.

Fig -2: A view of HUD with all the legends

2.3 REAL-TIME COMMUNICATION & VIDEO TRANSMISSION

Raspberry Pi – Flight Controller**:** To establish the communication process between Raspberry Pi and ArduPilot Flight Controller, We use the MAVLink Protocol over a serial connection. Few reliable & useful softwares that make use of MAVLink Protocol to send commands to the flight controller using Pi are:

- **MAVProxy** – can be used to send commands to the flight controller from the Pi. It can also be used to route telemetry to other network points.
- **Rpanion server -** a web-based GUI for configuring flight controller telemetry, logging, video streaming and network configuration. The Rpanion-server

image will have the serial port (UART) already enabled.

All of the above softwares use the MAVLink Protocol for communication.

UAV – UAV - GCS: In order to carry out drone to drone communication, we can use FPV repeaters, to transmit real-time video between the UAVs, and nRF24 transceivers to relay commands. This will assist us to map a larger area and **increase the effective range** of communication. At best case, the effective range can increase linearly with increase in the number of drones.

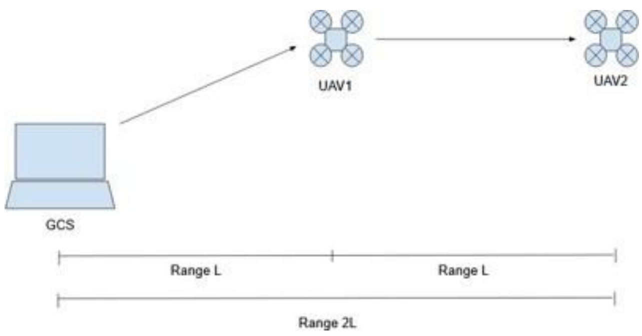


Fig -3: Range extension by relaying information

Another typical concern while piloting a drone is that radio waves may not pass through some obstacles like buildings, hills, metal structures, etc. This makes some parts of the region inaccessible as the vehicle may not respond here. Using multiple drones, it is possible to **communicate through a different path** via a relaying drone instead of direct line of sight. This can **bring more areas under coverage** which may otherwise be out of reach.

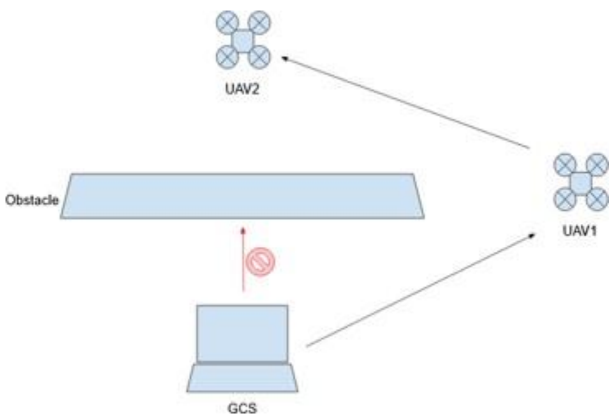


Fig -4: Accessing inaccessible areas

Additionally, the UAVs can transmit their location information on a regular basis. This way, if two drones come in the vicinity of each other, they can tweak their paths to avoid collision.

With the help of nRF24 Transceiver Module, we carry out communication between the UAVs & the GCS. nRF24 transceiver modules are popular for applications like RC vehicles & drones. They have a fairly large bandwidth and are capable of covering vast areas with manual control.

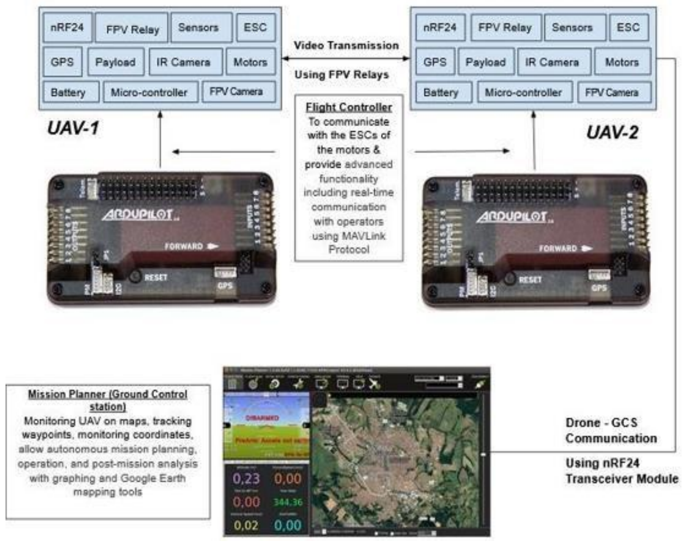


Fig -5: Overall interfacing of the flight controller with each other and the GCS

The above figure demonstrates the working of the system as a whole.

2.4 PAYLOAD DROP PROCESS

To achieve efficiency in supply drop process, we can use the UAVs to distribute multiple payloads to different locations simultaneously. Payload distribution can be managed by assigning the different kinds of payloads to different UAVs according to the need of the survivors. If the location at which a particular payload is required is found by a different drone, it can send that location to the appropriate drone directly. For instance, say a UAV carrying food discovers a location which requires blankets. Then this location can be sent directly to the nearest blanket carrying drone, which can then fulfill the demand. Additionally, requirements of the locations can be sent to the GCS on a regular basis, to create a list ahead of the next supply round. For the dropping process, the UAV will wait for the Ground Control Station to communicate the target location coordinates. Upon receiving the target location, the UAV makes adjustments to its trajectory such that that it is now in a straight line passing over the target location. The UAV then evaluates the release point by assuming constant wind velocity & it's altitude from the current point to the release point. The dropping mechanism is triggered after ensuring that the correct location is reached with the help of an onboard camera, which relays real-time video and data back to the Ground Control Station.

3. FUTURE SCOPE/ ENHANCEMENTS

- This system makes use of FPV relays and nRF24 transceivers to achieve drone to drone communication. In the future dedicated radio modules and communication protocols for this purpose can be developed to pass information from one UAV to another. Such modules will make future versions of the system much more efficient and reliable. This has the potential to open up a whole new branch of drone components.

- Lagrangian sensors can be another great addition to the system. These are relatively new, small buoyant sensors which are used to detect and monitor short term upcoming floods. Swarms of UAVs can be used to deploy Lagrangian sensors in strategic locations. The information from these sensors can be used to predict an upcoming flood beforehand and take the necessary measures.

- Strong Machine Learning algorithms like Neural Networks can help achieve a more autonomous flight since manually controlling multiple vehicles can get complicated. Such algorithms can help in many tasks like obstacle avoidance, trajectory planning, computer vision, etc. As the system uses multiple UAVs, much more amounts of raw data (proportional to the number of vehicles) from all their flights will be available. This can help to train the models even better and achieve greater accuracy.

4. CONCLUSION

We have covered how a flooded area can be managed better using a network of UAVs working together as opposed to a single UAV. Different areas can be surveyed simultaneously and the effective range of the system can be increased. Payload distribution can be improved as well. We have proposed the component specifications according to our speculated system, however, the specifications of the final system may vary depending on the real world test conditions and the standard specifications available in market. Also, this system is not limited to flood management. With required modifications, similar systems can be created for other types of disaster management like earthquakes, forest fires, etc.

REFERENCES

[1] K.VV.M ani Sai Kumar, M d SohailD and Dr. Usha Rani. Nelakuditi, "Crowd Monitoring and Payload Delivery Drone using Quadcopter based UAV System," ICSSIT 2018, doi:10.1109/icssit.2018.8748421

[2] Swiss Foundation for Mine Action (FSD). "Drones in Humanitarian Action: A Guide to the Use of Airborne Systems in Humanitarian Crises". Geneva: FSD; 2016.

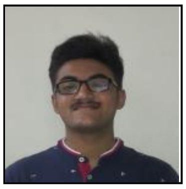
[3] B.Clusters (ed.), "The Future of Drone Use, Opportunities and Threats from Ethical and Legal Perspectives", e-book, ASSER Press.

[4] John Reid, https://www.rotordronepro.com/guide-multirotor-motors/#visitor_pref_pop

[5] Jingxuan Sun, Boyang Li, Yifin Jiang and Chih-Yung Wen "A Camera-Based Target Detection and positioning UAV system for Search and Rescue Purposes," 2016 Nov, doi: 10.3390/s16111778

[6] L. R G. Carrillo, et at, "Quad Rotorcraft Control: VisionBased Hovering and Navigation", Springer, 2012.

BIOGRAPHIES



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