A Hybrid Unmanned Aerial Vehicle With A Rover For Disaster Rescue Management Operation

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Abstract: The present invention proposed in this paper is a multi-role UAV with in-built Rover for Disaster Rescue Management (DRM) operation. As we know, Disaster Rescue operation are very complex, difficult and time consuming. The loss of human life during such operations after a disaster has been an area of concern for various organizations. In places with heavy rainfall and bad weather, DRM operation becomes an uphill task. The proposed invention is a hybrid UAV with an in-built Rover capable of image capturing with live feeds to the remote central station and thermal image capturing capability. The system is built such that, in case of heavy debris and landslide where Rover operation can’t be initiated at starting due to blockage of path for rover to move, the UAV is initiated and the Rover takes over when is clear path is visible. The device is equipped with GPS (Global Positioning System) with sends the location to the central system or remote command Centre whenever the image capturing system detects a heat signature through thermal imaging. In case of GPS failure, the system is developed with secondary back up which drops a sensors marker which the remote unit can track. The system proposed here is developed with an aim of reducing the loss of human life and increase effective DRM operation which reduces the time taken for search and rescue operation.

1. Introduction

The present invention described here is one of a kind, hierarchically arranged device proposed for the DRM (Disaster Rescue Management) operation. Disaster Rescue operation are very complex and difficult. The loss of human life during this operation has been an area of concern for various organizations. In places with heavy rainfall and bad weather, DRM operation becomes an uphill task [1]-[3]. The proposed invention is a hybrid UAV with an in-built Rover capable of image capturing with live feeds to the remote central station and thermal image capturing capability. The system is built such that, in case of heavy debris and landslide where Rover operation can’t be initiated at starting due to blockage of path for rover to move, the UAV is initiated and the Rover takes over when is clear path is visible. The device is equipped with GPS (Global Positioning System) with sends the location to the central system or remote command Centre whenever the image capturing system detects a heat signature through thermal imaging. In case of GPS failure, the system is developed with secondary back up which drops a sensors marker which the remote unit can track. The system proposed here is developed with an aim of reducing the loss of human life and increase effective DRM operation which reduces the time taken for search and rescue operation.
2. Unmanned Aerial Vehicle Communication Networks & Surveys

As of late there have been expanding interest in aeronautical correspondence networks as appeared by exploration and industry endeavours. Distinctive use cases have been imagined for aeronautical network sending, including public wellbeing, to give inclusion and ability to work force during crisis also, brief enormous scope occasions, and Internet network in arising nations. A few tasks have dispatched activities to contemplate the chance of utilizing elevated stages for giving remote administrations. Considering high and low altitude platforms, where drones and airships are being used for deploying wireless communications go with the terrestrial infrastructure. Generally, UAVs can be sorted mainly, based on their altitudes, such as High-Altitude Platforms (HAPs) and Low Altitude Platform (LAPs). HAPs have altitudes which is considered above 17 km and are semi-stationary [4][5]. On the other hand, LAPs can have analtitude of 10 kilometres, which can move quickly, and are flexible. There are various exciting applications for using different types of UAVs for wireless network communication purposes that have spawned over numerous research areas. S. Chandrasekharan et.al[6] report the design and implementation challenges faced for an aerial network communication for based stations with LTE Advanced (LTE-A). In this aerial platform, a comparison is carryout for wireless communication systems like drones, aircraft, airshift and tethered Helikite based on various capabilities and also proposed compelling trend of radio communications wireless networks using aerial platforms. M. Mozaffaria et.al[7] reported the potential benefits, challenges, fundamental trade-offs and applications of UAV enabled wireless communications network is thoroughly investigated.

Survey on UAV Communications Systems focusing on area of wireless network communications like Multi-layered UAV with ad-hoc Network [8][9], IoT based network communication for UAV [10], Design Mechanisms & Protocols for airborne network communications [11], UAVs used for Civil applications[12], Cybersecurity Applications[13], Multi-Tier drone Network[14]. The drawbacks in the survey on UAV Communications Systems overcome with proposed for Disaster management & Rescue System applications.

3. Proposed Hybrid UAV System

3.1 A. Proposed system for hybrid UAV system

This project can be divided mainly into three subsystems namely, Subsystem A, B and C with each subsystem having its own task and function. Subsystem A is mainly the UAV unit, consisting of Power supply unit, the PSU feeds the power to the Power distribution board for the power to reach different motors for the propellers to rotate. [15] The heart of the system Flight controller unit is also connected to the power distribution board through which supply is fed to it as mentioned in Figure 1. The receiver is connected to the flight controller. The communication between the receiver and transmitter is established between a 2.4Ghz remote link consist of power supply unit which consists of Solar panel, Charge controller and battery thus providing the system with two-way powering. Subsystem B is the central processor and Broadcasting unit. This subsystem the main unit as it runs the intelligent algorithm, which analysis the data collected and then transmits it to the meteorological department. Finally, the subsystem C consists of the sensing unit as shown in Figure 2. The sensing unit extracts the weather and pollution data which is then send to central processor for analysis using the algorithm for the respective departments to analyze the entire situation prior to take actions so they can be fully prepared before commencing the rescue operations.
Figure 1. Functional Diagram of Proposed System of the Drone [15].

The system is designed such that it is powered using solar and rechargeable battery using charge controller. First when the system is initialized the algorithm starts the data extraction as shown in Figure 3. Initially the System checks all the parameters for a safe flight and initiates the Rover or The Drone depending on the surrounding conditions. Once one of the system is initiated, The live video feeding begins with help of the Raspberry Pi with various cameras. Along with this GPS data analysis is done with the captured video and Images. As a fails safe mode, Once activated in case the drone gets damaged in uncertain condition the location where the Drone lost contact is immediately marked to the rescue team so they can recover it if possible, so that the accurate data stored by the Drone can be acquired for Disaster Analyzation for future references and study for Disaster Management teams. The entire Drone is specially waterproofed such that it can fly even in rainy conditions and do the survey and send the required data to the Rescue Management Team.
Figure 2. Functional Block Diagram of Sub System of UAV & Rover unit B & C[15].

Figure 3. Flowchart of Proposed Hybrid UAV for DRM System[15].
3.2 B. Mathematical Analysis for Thrust calculation for UAV:

The hybrid UAV thrust calculation configuration has to be considered and designed using propellers details, power consumption, thrust-weight ratio, thrust efficiency for enhancing the Quad copter efficiency and also ensure about the flight time endurance[16]-[17]. ecalc.com software is used as propellar calculator, and help to find out the motor characteristics and thrust efficiency.

Figure 4. Orientation Image of Quadcopter Flight

General mathematical formula which are used in drone technology are

- Propeller efficiency \( J = \frac{V}{nD} \), where \( V \) is the aircraft forward speed, \( n \) and \( D \) are the rotational speed in rev/sec and diameter of the propellor respectively.
- Quadcopter flight times \( \frac{\text{Battery Capacity} \cdot \text{Battery Discharge}}{\text{Average Amp Draw}} \times 60 \)
- Thrust=2 * Total weight of model.
- Payload Capacity = (Motor thrust \( \times \) Number of motors used \( \times \% \) of Hover Throttle ) – motor weight
- Power consumption = Amps x Volts = Watts AUW (all up weight) = \( \frac{1}{2} \)thrust (around)

Where continuous current of 1 amp= 1000 mah
Figure 5. Parameter Calculations of Quadcopter

Figure 6. Range Estimator Characteristics
The Prototype of Done is developed on a modified F450 frame which can integrate the Rover unit as shown in Figure 8. We used 1000KVA BLDC motor and 10*45 propellor for the drone along with ESC for speed control of the motor. The flight controller used in this project is Pixhawk with GPS and Telemetry enabled to track location and transfer data to main server point. The entire drone is powered by a 5200 mAh Lipo Battery for a flight time up to 25 minutes. A Flysky FS-i6 2.4Ghz and 6 channel radio is used to control the drone manually. The Drone is developed in such a way it can withstand all kinds of weather as all the components of the drone is specially water proofed. Few of the data from Pixhawk GPS is the transferred to the Raspberry Pi Unit.

The Rover is built using acrylic board, the rover has 4 legs consisting 3 servos each. The rover is controlled by an Arduino Uno mounted along with Servo control board to an nRF24101 Module which is a 2.4GHz radio. The user will have a separate 2.4Ghz control panel to control the rover. The rover is designed in such a way that it can climb or walk through any given terrain with proper balance. It is powered by a separate 3000maH power Bank shared with Raspberry Pi.

This unit consist of Raspberry Pi integrated with its thermal and High-definition camera for 2 types of Image recordings. The raspberry Pi collects the entire Drone Data and transfers to the main Data Center for further process.
Figure 8. Developed Prototype of Hybrid UAV With A Rover For DRM Operation[15]

4. Conclusion

As time is very precious during Natural Disaster and the time taken for rescue management team to analyze the situation is quite more depending on the situation and place of disaster before sending the required team and equipment’s. This paper presents a new UAV within built rover for DRM Operation. The proposed system can cut down the time more than half of the present and give more accurate data for preparedness. This project helps to create the case for multi-drone autonomous operations because our operations model is capable of scaling up and ingesting the info coming from quite one drone at a time for search and rescue programs with more cost efficient and reliable.

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