Modular Rescue and Surveillance Drone

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Abstract - *Nowadays, drones or more specifically Multi-rotors are an important technology being used in various fields and in many different ways, military is one of the fields that uses UAVs extensively in Surveillance and Rescue operations [2]. One of the limitations faced in such operations is that, some areas cannot be accessed by just the flying ability of drones, in order to make these areas accessible, drones also need to have the ability to navigate on ground like a car. A mechanism to make a drone navigate on ground surface can be easily added, but the weight of the drone also needs to be kept as low as possible to have a longer flight time and high payload carrying capacity. So, a different methodology must be adapted rather than adding motorized wheels. In this paper a different approach is shown, that adds the ability to navigate on ground by just tilting the motors. To demonstrate the approach the mechanism is implemented on a Quadcopter. Additionally, implementation of a LiDAR based 3D-Mapping feature on the drone is discussed, which is capable of creating a 3D-Map of the environment. Furthermore, a feature to add and drop different modules for different applications is explained.*

Key words: Drone, Robotics, Surveillance, Military, LiDAR 3D-Mapping, Modular.

1. INTRODUCTION

Drones being only able to fly, make some areas difficult to be accessed during operations like rescue and surveillance. Hence a mechanism must be developed to add the ability to navigate/move on ground as well, while keeping the weight of the drone as low as possible. So instead of using additional actuators for wheels, the already present actuators i.e. the brushless motors can be used to propel the drone forward and backward. This can be done by tilting the motors using a servo motor. Also, as a drone for rescue and surveillance operation is incomplete without a way to visualize the area and carry payloads, so a 3D-Mapping device based on LiDAR and a slot to attach different modular devices is developed and added to the system. To demonstrate these features, they are implemented on a 250mm H-Frame Quadcopter.
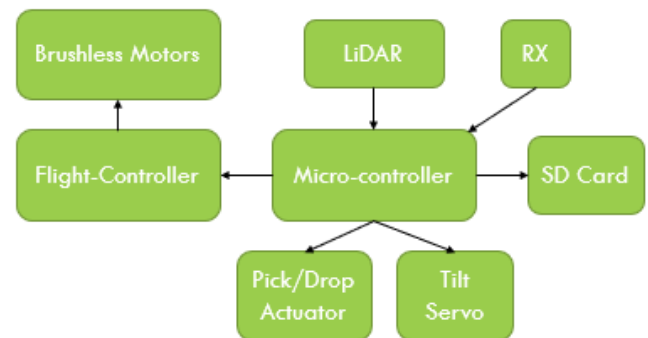
2. BLOCK DIAGRAM

Fig -1: Block Diagram

The Fig – 1 shows the block diagram of the overall system. The drone has two operable modes: Air Mode and Ground Mode. The Flight controller takes care of the drone when required to be airborne in air mode and the Micro-controller is responsible for: switching between the Air and ground mode, control of drone in ground mode and enabling or disabling other features. The control signals from receiver RX for directions are given to both, the microcontroller and the flight controller, but the control signal to switch between air and ground modes and enabling other features is given to the micro-controller only. In air mode the microcontroller passes the control of drone to the flight controller, and in ground mode the microcontroller keeps the control with itself and tilts the front and the rear arms as required. Features like 3D-Mapping and activating Modular attachments is available when in ground mode. The flight controller is a completely separate board that uses the data from the onboard Gyroscope and Accelerometer as feedback for a PID controller to stabilize the drone. The signals from the receiver are Pulse Width Modulated (PWM) signals of 1000-2000 micro-seconds.

3. GROUND MODE: NAVIGATION ON GROUND

To add the ability to navigate a drone on ground surface like a car with wheels, the mechanism is developed considering factors such as the size of the drone, space available, weight of the drone and battery capacity. One simple approach was to add motorized wheels, but this will add up a lot of weight as well as consume space. Hence a different approach is implemented, in which, the already

available actuators i.e. the brushless motors are used. A special tilting mechanism is implemented, which tilts the front and the rear arms containing the brushless motors, 45 degrees clockwise or anti-clockwise depending on the direction to navigate. In such a tilted orientation, motors when turned ON, the thrust produced is in not perpendicular to the ground, but it at a 45 degrees angles with the ground. This makes the drone propel forward if arms are tilted anti-clockwise or backward if arms are tilted clockwise, because there exists a horizontal component of the thrust which is enough to propel the drone on the ground with the dead wheels attached to the frame. There also exists a vertical component of the thrust, but it is not enough that it can lift the drone up in the air. Hence the drone remains on ground and is able to move on ground surface. The Fig –2 shows the drone in the ground mode.
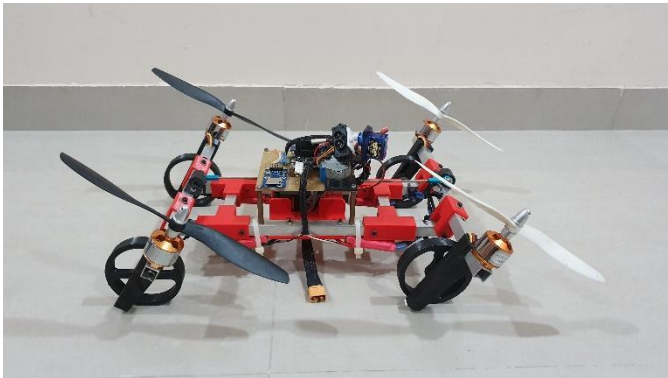

Fig -2: Ground Mode

3.1 TILT MECHANISM

The tilt mechanism for arms is built using a 20kg-cm Servo motor, with span of 180 degrees. The servo is connected to the front and the rear arms with two link rods with ball joints. The change in servo angle causes one link rod to push one arm and the other link rod to pull the other arm, causing tilts in the arms. The Fig –3 shows the frame with just the tilt mechanism.
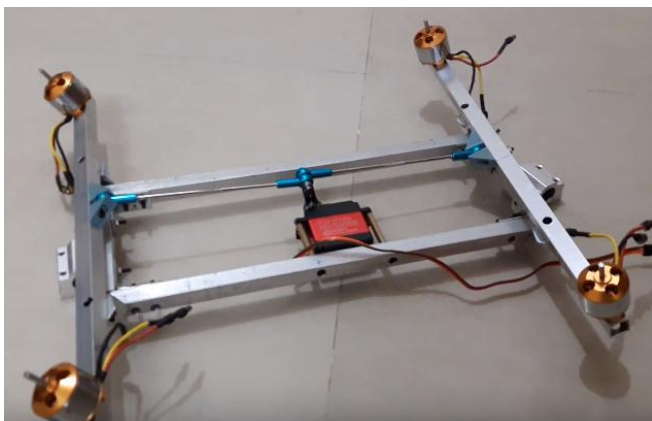

Fig -3: Tilt Mechanism

4. AIR MODE

In this mode the arms of the drone are held in upright position by the servo, i.e. the servo is maintained in 90 degrees position by providing a 1500 micro-second PWM pulse. Holding the arms in upright position, allows the motors to pull the air or provide thrust perpendicular to ground surface, which lifts the drone up in the air. The Fig –4 shows the drone in the air mode.
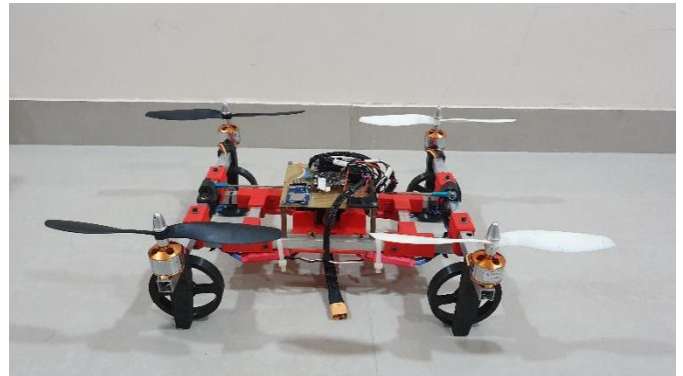

Fig -4: Air Mode

4. 3D-MAPPING WITH LIDAR

Almost all drones are equipped with a camera, but a camera provides only 2D information of the environment. A 3D-Map of the environment is more informative, as it provides the depth information as well, and also is a very necessary [1] feature for a rescue and surveillance operation.
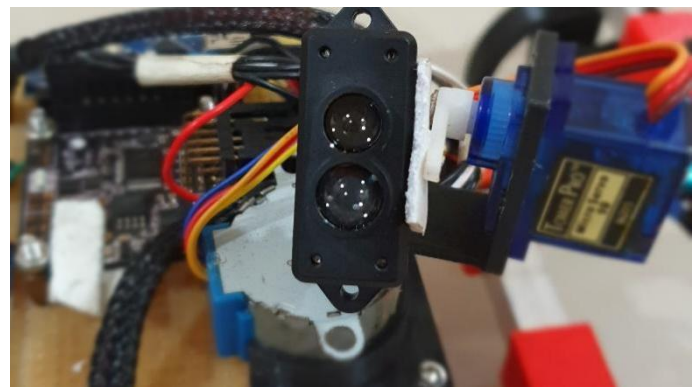

Fig -5: 3D-Mapping Mechanism

To build a 3D-Mapping device, a LiDAR is attached to a servo which is further attached to a stepper motor. This configuration allows the LiDAR to be rotated in such a way that the upper hemisphere of the area is mapped. The stepper rotates 360 degrees whereas the servo rotates 90 degrees. After each 360 degrees rotation of the stepper motor the servo angle is incremented by 1 degree, hence the area mapped is a hemisphere. The LiDAR keeps on collecting the depth information while it is being rotated and the depth data along with the azimuth and elevation is

stored on a SD Card. This RAW data on the SD Card is then visualized using an online software as shown in Fig -6.

Fig -6: Online LiDAR Data visualization

5. MODULAR ATTACHMNETS

Most of the time in such operations a drone needs to carry payload or other instruments along with it. To accommodate them, a slot for modular attachments like pick & drop module or other sensors is provided.

6. CONCLUSION

This paper presents an innovative methodology and solution that enables a Quadcopter with a generic configuration to move on ground surface like a car and enhance the Rescue and Surveillance operation. The combination of Hardware and Software together governed with a Control Systems algorithm allows the Quadcopter to switch between different modes: Ground Mode and Air Mode. The Spotlight feature, the Ground Mode adds in the ability to navigate on the ground without any additional motors or actuators, and without adding much the weight of the drone and also saving some room for other features. This makes the Quadcopter capable of moving forward, backward and turning on ground surface. Additionally, the LiDAR based 3D-Mapping feature helps to map the environment around the drone. Furthermore, the slots available for modular attachments, add the capability to carry payload using pick and drop mechanism and also attach different instruments.

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