REMOTE SENSING EMBEDDED IN AUTONOMOUS UNMANNED AERIAL VEHICLE

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Abstract - In recent studies, several approaches have been proposed for object detection in autonomous vehicles. In this paper, we present our unmanned aerial vehicle implementation which gives a solid solution to this problem in an efficient manner, using a Raspberry Pi and a LIDAR module for indoor navigation. We present the development of an affordable Unmanned Aerial Vehicle-Light Detecting and Ranging (UAV-LiDAR) system and a related advancement to produce 2D mapping. The vehicle is capable of mapping and navigating in an unknown environment by detecting objects. The developed 2D space mapping needs an accurate position for the creation of a space map. We performed various experiments and verified the success of our implementation.

Key Words: *unmanned aerial vehicle, Raspberry Pi, LiDAR, obstacle avoidance, Indoor mapping*

1. INTRODUCTION

Quadcopters (otherwise referred to as quad-rotors) aircraft are emerging choices in Unmanned Aerial Vehicle (UAV) draft. This is often due to their capacity to drift in crowded areas and Vertical Take-Off and Landing (VTOL). Quad-rotor consists of 4 rotors that are hooked at the tip of the frame arrangement. Here the front and rear motors rotate counterclockwise and also the other two rotates clockwise, as a result of the online aerodynamic torque is going to be 'zero'. Each rotor is connected to fixed pitch propellers.

The movement of the quad-rotor is controlled by the speeds of the four motors to negate the consequences of counter-rotational torque from the motors; there are opposing rotations on the various axes. This causes a net torque of zero, cancelling out the unwanted rotation. Keeping the whole torque capable zero is critical for controlled flight. Vertical movement is made by increasing the speed of all four motors equally. Movement within the positive Y direction for instance is completed by increasing the speed of motor 3 while decreasing the speed of motor 1. This keeps the web torque zero while causing the craft to tilt allowing movement without rotation. The lean however will cause the lifting component of the thrust to scale back, requiring an equal increase of all four motor speeds to compensate. Controlled rotation is often caused by increasing the motor speeds on one axis while decreasing the motor speeds on the opposite, thus causing the torque to travel out of balance.

2. LiDAR-BASED MAPPING

The area we are keen on here is that the distant detecting and every one the more explicitly when this procedure is employed installed on rambles. The utilization of airborne LiDAR has received significant research attention and operational use as a source of data for forest scientists since its introduction within the mid-1990s. This has allowed a well-defined best practice data collection and processing workflow to be established by data providers. The foremost important requirement for a drone, especially when flying beyond a visible line of sight, is safety including the power to autonomously and adaptively mapping the method. The battery needs to be large enough to confirm a sufficiently long flight time, the control strategy should be easy to implement within the controller, and also the drone should be able to lift the mandatory equipment.

The first section presents the fundamental mechanical components that structure the drone so it fits the preconditions. The second section presents the electronic components, just like the controller and components for autonomous flight, also as the way to founded these components correctly and calculate the minimum width of a detectable object. The third section presents the software design of the drone system.

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During the information, collection phase consideration has to run to the limited flight time of a UAV and optimal mapping strategies have to be determined. A plus of the platform utilized in this study is that the onboard autopilot allowing maximum coverage of the targeted area during each flight.

Fig-1: UAV system 1) LiDAR 2) Pixhawk 3) Raspberry Pi

3. QUADCOPTER ELECTRONIC COMPONENTS:

1) Motors: Brushless DC motors (BLDC motors) are utilized in Quad-rotor. The motor features a static magnet that rotates around a hard and fast point. Advantages over BLDC are more torque per weight, reduced noise, increased reliability, longer lifetime, and increased efficiency.

Motor calculations: The motors should be selected in such how that it follows the following thrust to weight relationship.

Ratio = (Thrust / weight) = (ma / mg) = (a / g)

VTOL is feasible only if (a / g) > 1 or in other words, the whole thrust to total weight ratio should be greater than 1 so the quadcopter can accelerate within the upward direction.

Total Thrust Produced = 2*(Total weight of Quadcopter)

2) Propellers: A propeller may be a form of fan that converts rotational energy into thrust. Generally, propellers may be classified as supported by their diameter and pitch. The diameter of the propeller indicates the virtual circle that the prop generates whereas the pitch indicates the number of travel per single rotation of the propeller. To counter motor torque, Quad-rotor requires two clockwise and two anticlockwise rotating propellers. All the propellers utilized in the quadcopter should have identical diameters and pitches.

3) Electronic speed controllers: this is often also called ESC. ESC is employed to drive the motors at a particular speed by supplying a particular amount of current and voltage.

ESC rating = [1.2 to 1.5]*(max. ampere rating of motor)

4) Battery: Quad-rotors mainly use Lithium Polymer (Li-Po) batteries. the most purpose of using these batteries is that they are rechargeable and even have low weight and high voltage capacity as compared to other sorts of batteries.

Battery calculations:

Maximum Current withdrawal by motors = (no. of motors) * (maximum current withdrawal by single motor)=(4*15)=60 A

Rule- The discharge current from the battery should be over the utmost current withdrawn by the motors.

Where, discharge current = (Capacity in ampere) * (discharge rate).

Flight time = (Capacity in amperes/Current draw) * 60

5) Flight controller: To keep up the balance, the quad-rotor should continuously take measurements from the sensors and adjust accordingly to the speed of the rotors to stay at the body level. The 2 main factors to be considered while selecting a flight controller are flying capabilities and price. Flying capabilities are often considered by following basic factors-

Gyro stabilization: it's the power to stay the copter stable and level under the pilot control.

Self-levelling: it's the flexibility to automatically adjust itself during any stabilization so that the copter stays level.

6) Transmitter and receiver: The Transmitter (Tx) and Receiver (Rx) system allows the quadrotor to be remotely controlled through a wireless signal. The aircraft controls would typically include throttle, pitch, roll, yaw, and mode settings. 2.4GHz TX and RX systems are used for his or her better performance. The receiver used has a 6C 2.4 GHz system which is perfectly bonded with the two.4GHz transmitter.

4. CONTROL SYSTEM:

To be able to add other components and implement developed control methods on the drone with stable flight, the controller should be flexible to use and for this, an open-source flight controller is employed, named PIXHAWK 2.4.8. This controller equips with a 3D gyroscope, an accelerometer and, a barometer. Other installed equipment includes telemetry for data exchange with a ground station, an FSi6 receiver for manual control, a 7M GPS module with an enclosed compass for outdoor navigation, and a Raspberry Pi 4 (4 GB RAM) to run the algorithm. And for mapping the environment LIDAR A1 is employed. LIDAR A1 could be a minimal effort 360-degree 2D laser scanner (LIDAR) arrangement created by SLAMTEC. The framework can play out a 360degree sweep inside a 6meter territory. The created 2D point cloud information may be utilized in planning, limitation, and article/climate displaying.

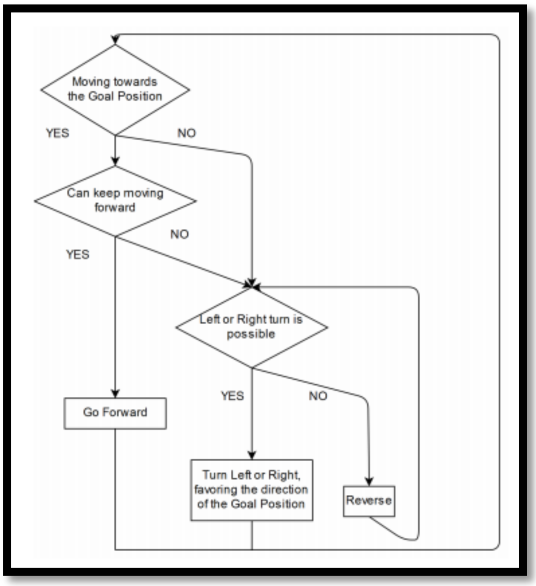

Fig-2: Decision making algorithm

5. SOFTWARE COMPONENT:

To control the drone through the RPi, first, the RPi should communicate with the drone's flight controller through MAVLink (Micro Air Vehicle Link) protocol. To do so, MAVProxy, a MAVLink ground station written in Python and C++, is installed within the RPi OS (Raspbian OS) to translate readable commands into MAVLink command messages. To streamline and make automation easier, a Python-based module named DroneKit, a group of drone APIs with underlying functionality to manage a drone, is employed on top of MAVProxy to achieve easier access to the command library of the drone. Thus, the controlling algorithm can run onboard and send commands to the drone through the DroneKit framework.

In this project, we've got some software to investigate our project results. The software details are PUTTY, UNCSERVER, RVIZ, and ROS NOETIC but here we've got used putty software for analyzing results about the project.

Software Procedure

- Configure mobile hotspot name and password
- Switch on the hotspot & connect to the laptop
- Power on the drone & wait for RPi connection establishment
- Open putty and connect SSH via IP address
- Enter credentials
- Type UNC server and hit enter
- Open UNC server and connect to remote desktop with RPi IP address
- Open terminal
- Type roscore and hit enter
- Open another terminal and type the launch code
- Turn on the transmitter
- Turn on the safety switch
- Arm drone
- Now we're ready to fly

6. RESULT:

In this study, preliminary results of the performance of the adaptive object detection in 2D are shown. The communication between the displayed image and also the neural control network is predicated on the Robot package (ROS). With this implementation, the controller can easily be transferred to the important drone hardware. Quantitative tests in numerous environments with an occasional density of objects, a high density of objects, and a high density of objects corners and deadlocks may be also seen. There, we observed that the drone had 100% success to navigate with a coffee density of obstacles, 90 so successful within the environment with a high density of obstacles, and 90 so successful within the environment with a high density of obstacles besides as corners and deadlocks.

7. CONCLUSION:

In this paper, an unmanned aerial vehicle using Pixhawk 2.4.8, Raspberry Pi, and LIDAR is presented. The vehicle is capable of utilizing existing Wi-Fi infrastructure to locate its position in the environment and navigate safely from a starting point to a destination point while detecting obstacles. Our work could be further enhanced by implementing a 3D mapping feature to generate an image of the environment during navigation.

8. FUTURE WORK:

Although future developments of this system (including hardware and battery technology) will increase flight endurance, the current system is capable of flying multiple transects over an indoor plot in a single flight. These results have confirmed that our UAV-LiDAR system is a suitable platform for the generation of high-resolution point clouds for assessing forest structure at the individual tree level.

REFERENCES

1. Devos, Arne, Emad Ebeid, and Poramate Manoonpong. "Development of autonomous drones for adaptive obstacle avoidance in real world environments." 2018 21st Euromicro Conference on Digital System Design (DSD). IEEE, 2018.
2. Jeong, Nulee, Hyun Hwang, and Eric T. Matson. "Evaluation of low-cost lidar sensor for application in indoor uav navigation." *2018 IEEE Sensors Applications Symposium (SAS)*. IEEE, 2018.
3. Malina, Marek, and Jaroslav Zacek. "An Indoor Space Mapping with a Drone." *IT for Practice 2019* (2019): 63.
4. Belcore, Elena, et al. "RASPBERRY PI 3 MULTISPECTRAL LOW-COST SENSOR FOR UAV BASED REMOTE SENSING. CASE STUDY IN SOUTH-WEST NIGER." *International Archives of the Photogrammetry, Remote Sensing & Spatial Information Sciences* (2019).
5. Thielicke, William, et al. "Towards accurate and practical drone-based wind measurements with an ultrasonic anemometer." *Atmospheric Measurement Techniques* 14.2 (2021): 1303-1318.
6. Moskalenko, Viacheslav, et al. "The model and training algorithm of compact drone autonomous visual navigation system." *Data* 4.1 (2019): 4.
7. Kumar, K. Senthil, M. Venkatesan, and S. Karuppaswamy. "Lidar-aided Autonomous Landing and Vision-based Taxiing for Fixed-Wing UAV." *Journal of the Indian Society of Remote Sensing* (2020): 1-12.
8. Zheng, Lanxiang, et al. "The obstacle detection method of uav based on 2D lidar." *IEEE Access* 7 (2019): 163437-163448.
9. Zheng, Lanxiang, et al. "The obstacle detection method of uav based on 2D lidar." *IEEE Access* 7 (2019): 163437-163448.
10. Lee, Sedam, and Yongjin Kwon. "Safe Landing of Drone Using AI-based Obstacle Avoidance." *International Journal of Mechanical Engineering and Robotics Research* 9.11 (2020).
11. Gupta, Siddhartha, and Umut Durak. "RESTful Software Architecture for ROS-based Onboard Mission System for Drones." *AIAA Scitech 2020 Forum*. 2020.
12. Alon, Alvin Sarraga, Enrique D. Festijo, and Cherry D. Casuat. "Tree Extraction of Airborne LiDAR Data Based on Coordinates of Deep Learning Object Detection from Orthophoto over Complex Mangrove Forest." *International Journal* 8.5 (2020).