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Customization of UAVs and Calibration of the Data Acquired by a Lidar Sensor

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Abstract—*Unmanned Aerial Vehicles are a part of the state-of-the-art technology. Their use and applications are many in today's scenario. The UAVs give us an extra dimension in the studies wherein one can get in situ data for further processing without time-lag.*
To begin with, for the present study, a UAV, was indigenously assembled, its performance parameters and cost was compared with those readily available in the market. This UAV was designed to mount a sensor. The weight limit of the sensor that could be mounted was also calculated. The parameters which could be measured, considering, the speed turbulence of the rotors is also discussed. For starters, a readymade Lidar sensor was mounted to check the authenticity of the data acquired.

Keywords: *UAV (Unmanned Air Vehicle), Lidar, DTM (Digital Terrain Model), DSM (Digital Surface Model)*

INTRODUCTION

Drones equipped with LiDAR (Light Detection and Ranging) technology represent a groundbreaking advancement in aerial data collection. By integrating LiDAR sensors onto unmanned aerial vehicles (UAVs), these systems enable rapid, efficient, and highly accurate 3D mapping of terrain, vegetation, and structures from above. The LiDAR sensor emits laser pulses towards the ground and measures the precise time it takes for the light to return, allowing for the creation of detailed point cloud models of the Earth's surface. This technology offers unparalleled insights into terrain elevation, vegetation structure, and building features, making it invaluable for a wide range of applications such as surveying, mapping, forestry management, infrastructure inspection, and environmental monitoring. With the ability to access remote or hard-to-reach areas and fly at low altitudes, drones equipped with LiDAR provide flexibility and mobility in data acquisition, while also offering cost-effective and time-efficient solutions compared to traditional surveying methods. As regulations evolve and technology continues to advance, the integration of LiDAR with drones is poised to revolutionize industries, unlocking new opportunities for data-driven decision-making and analysis.

But this technology comes with a big price, lidars with drones are very expensive it is hard for small individuals or small organizations to afford. So, to overcome this problem, this UAV is designed.

AIMS AND OBJECTIVES

Develop a drone equipped with LiDAR for aerial mapping and surveying applications & enhance data collection efficiency for surface mapping applications.

- Design and fabricate a lightweight and aerodynamic drone platform capable of carrying LiDAR equipment.
- Integrate LiDAR sensors, GPS, and other necessary components onto the drone platform while maintaining balance and stability.
- Implement robust communication and control systems to enable remote operation and autonomous flight capabilities.
- Optimize LiDAR sensor configurations and flight parameters to maximize data acquisition coverage and resolution.
- Evaluate and refine the drone's performance through field testing and validation against ground truth data.

METHODOLOGY

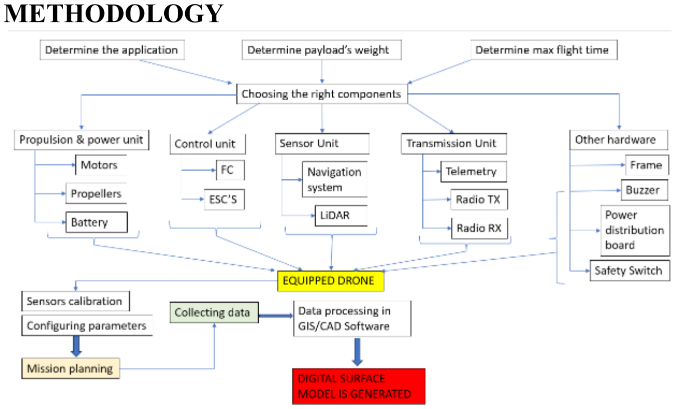

Figure 1: Block diagram of essential parts of a UAV

SELECTING EQUIPMENT

Quadcopter type UAV is chosen. At first, the payload, flight-time, and application are determined, then calculated how much thrust is needed.

The total thrust of all the four motors should be double of the MTOW, for better efficiency i.e.- thrust to weight ratio should be 2:1.

In our model, the MTOW is **1500 gram**, and each 2212 1000kv BLDC motor with 10 inch(diameter) & 4.5inch(pitch) with 12.6v battery, the thrust is approx**. 800 gram** per motor [by bench testing] so, total thrust = 800*4= 3200 (2.13:1). Fig.2

Motor	Type	kv	Batt	Prop
XXD	2212	1000	3S 5200 30C	1045
V	A	W	Thrust (gr)	g/W
12.45	2.00	24.90	200	8.03
12.42	2.85	35.40	250	7.06
12.39	3.38	41.88	290	6.92
12.34	4.39	54.17	360	6.65
12.27	6.58	80.74	465	5.76
12.23	7.61	93.07	545	5.86
12.15	10.01	121.62	650	5.34
12.05	12.53	150.99	750	4.97
11.98	14.76	176.82	825	4.67

Figure 2: Showing selection of components

- Pixhawk 2.4.8 flight controller is chosen, as because it has wide variety of customizable options, good stability, and compact size,
- For positioning, M8N GPS is installed, capable of connecting 20 satellites for precise positioning.
- 433mhz, 100mw telemetry is used to get real-time on-board data to the GCS.
- 12.6v 5000mah custom made Li-ion battery pack is used, as it has high energy to weight ratio (230Wh/kg) as compared to lithium polymer cells with(200Wh/kg).
- 2.4 GHz, 6 channel Radio transmitter and receiver is used to manually control the UAV.
- TF02 pro LiDAR module is used for collecting data, it has a range of 40m.
- Polyamide nylon is used for light weight, durable and cheap option for frame.

2.2 Assembling the Drone

Assembling the drone involved meticulous attention to detail and precise execution to ensure its proper functioning. The process typically begun with selecting suitable components, including the frame, motors, propellers, electronic speed controllers (ESCs), flight controller, battery, and radio transmitter/receiver. With these components in hand, the assembly was proceeded by mounting the motors onto the frame, connecting them to the ESCs, and securing them in place. The flight controller is then installed at the top center of the frame and connected to the ESCs, receiver, and power distribution board. GPS and telemetry is also installed, following the provided wiring diagram (*openly available in google* [1]).Figure1 gives the Block Diagram. Careful attention is paid to ensure all connections are secure and components properly aligned. After assembly, sensor calibration, parameters setting, radio calibration, are done and thorough testing is done, including motor and control surface checks are done, and overall system functionality verification. Safety precautions are paramount throughout the process, with adherence to guidelines and regulations, cautious handling, and gradual testing of manual and autonomous flight in controlled environments is organized.

FLIGHT PLANNING AND EXECUTION

Mission planning of the drone was done using Ardupilot Mission planner [2]. A 50m*50m undulating area is selected in GCS, for mission planning, and grids are made with waypoints. The UAV is commanded that it should maintain a constant height with relative to the takeoff location, also it should hover in each waypoint for at least 5-10 secs, it is done so that the drone becomes stable over the waypoint while the LiDAR sensor is collecting surface to UAV height data using infrared laser pulses. The height data of all the waypoints with location is stored in SD card attached in flight controller.

The mission is continuously monitored live from GCS via telemetry module

PROCESSING THE DATA

After the mission is complete, the data is transferred to a computer, then it is processed in open-source GIS/CAD software.

FINAL OUTPUT

A Digital Surface Model is successfully generated of an area allowing for detailed analysis and visualization of topographic and land cover features. DSMs play a crucial role in understanding and managing the Earth's surface, enabling informed decision-making, and planning processes across diverse sectors and industries.

OBSERVATIONS AND CONCLUSIONS

While the drone was successfully assembled, its data was also calibrated. To increase the accuracy of GPS positioning, the authors, in future planning to work to integrate RTK or DGPS system for precision positioning. The material of the frame of the UAV can also be upgraded to lighter materials to enhance the weight of the sensor and increase the endurance of the UAV.

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