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# Design of LIDAR system for terrain mapping

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***Abstract*—Surface scanning is regularly alluded to as landscape examination when data identified with slant, perspective, viewshed, hydrology, volume, etc are being determined on raster surfaces. Terrain mapping is extensively used in commercial aviation for many real-life applications since they are able to reach remote areas for mapping purposes and other surveillance purposes. This work tends to implement terrain mapping in drones by scaling down these device parameters for enhancing its compatibility for drones. The landing and accessibility of drones are crucial in such areas where human surveying is difficult and hence this technology assists these drones for a safe and collision free take-offs and landings on rough terrains.**

***Index Terms*—Lidar, Drones, Hydrology, surveillance, collision free.**

## I. Introduction

Territory mapping includes first distinguishing and breaking down regular characteristics of Earth's surface and landforms that show up in satellite pictures and maps utilizing LiDAR innovation. LiDAR-an acronym of Light Detection and Ranging is an optical remote detecting innovation that estimates properties of dispersed light to get the distance and other data of a faraway object. It utilizes light as a beat laser to gauge variable separations to the Earth. These light wave got together with other data recorded by the airborne system produce exact 3-D information about the condition of the Earth and its surface characteristics. A LiDAR instrument fundamentally contains a laser, a scanner, and a specific GPS recipient.

This paper has the following flow of discussion: section II is dedicated to the Objective, section III is dedicated to Existing work or methodology, section IV is dedicated to Proposed work, System Architecture and Flowchart, section V includes the results and section VI includes the applications, section VII gives the conclusion while section VIII includes the References.

## II. Objective

Our principle objective is to scale down the device parameters of mapping technology for enhancing its compatibility for drones.To minimize the size of LIDAR and make it compatible for drones.To develop a technology which assists these drones for a safe and collision free take-offs and landings on rough terrains where human surveying is difficult.

## III. Existing Work

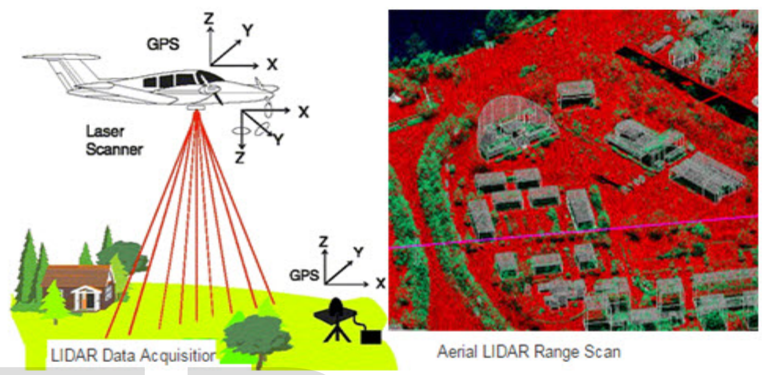


Fig.1a Lidar working in Aircrafts

Lidar technology is relatively huge for Drone and Unmanned autonomous vehicles used nowadays.Lidar due to its bigger dimensions are only available for use in Commercial and Military Aircrafts and can execute extensive terrain mapping in an industrial scale.
This is an example of how the terrain mapping system works on aircrafts.

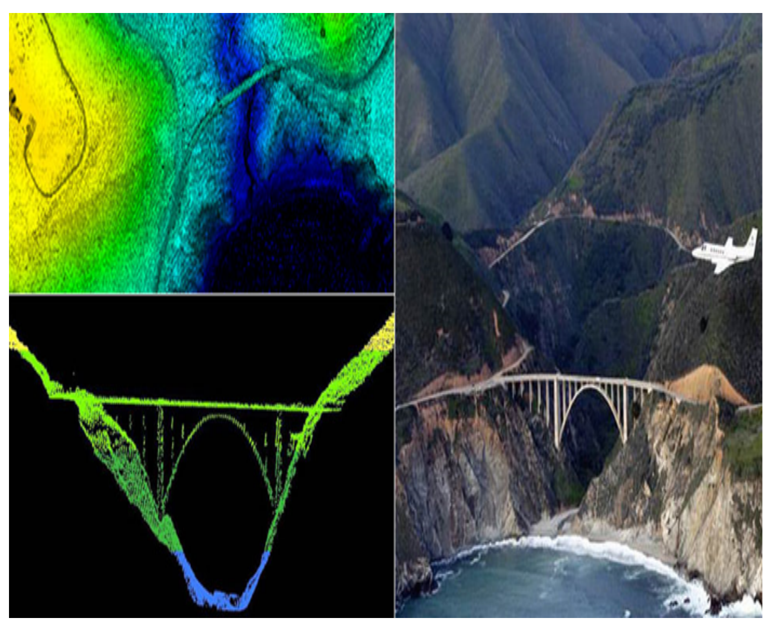

Fig.1b An example of terrain mapping in outdoor conditions

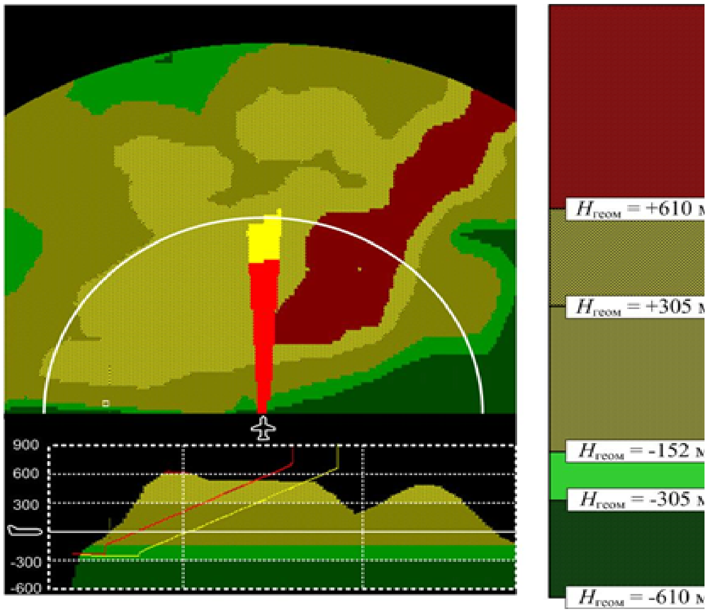


Fig.2 An example of terrain mapping in commercial aircrafts

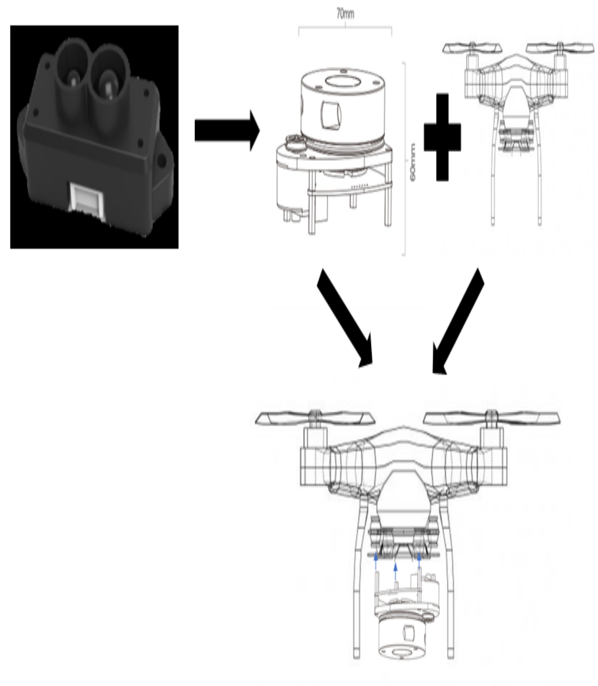

Fig.3 Phase by phase assembly of the lidar mount

There are some real-life constraints for the proposed work based on the condition under which it is used.

Fig.4 Distance measurement Setup

Indoor conditions: The article to be identified has 90 percent reflectivity and the feasible identification separation is 12m; The article to be identified has 10 percent reflectivity and the feasible identification separation is 5m;

Outdoor conditions:
Under the general sunshine condition, the effective detection distance is 7m

## IV. Proposed Work



### A. Overview

As of now, the terrain mapping technique using LiDAR technology is being currently used in commercial aircrafts and other large-scale aerial products, we aim to redesign the technology and make it compatible enough for daily usage DRONES which can be used for safer and hassle-free applications such as surveillance and remote-sensing.

Proposed work is a build-up on existing LiDAR technology, aiming to further redesign it by scaling down these device parameters for enhancing its compatibility for drones.

The novelty of the project lies on the existing technology of the LIDAR system which is needed to map the terrain of a surrounding that is being scaled down into the design specifications and constraints of a drone.

We aim to redesign the technology and make it compatible enough for daily usage DRONES which can be used for safer and hassle-free applications such as surveillance and remote-sensing.

### B. System Architecture

LiDAR system architecture consists of several major components like lidar transmitter, lidar receiver, timing control electronics, Newtonian telescope, position and orientation system (POS) and data processing system.

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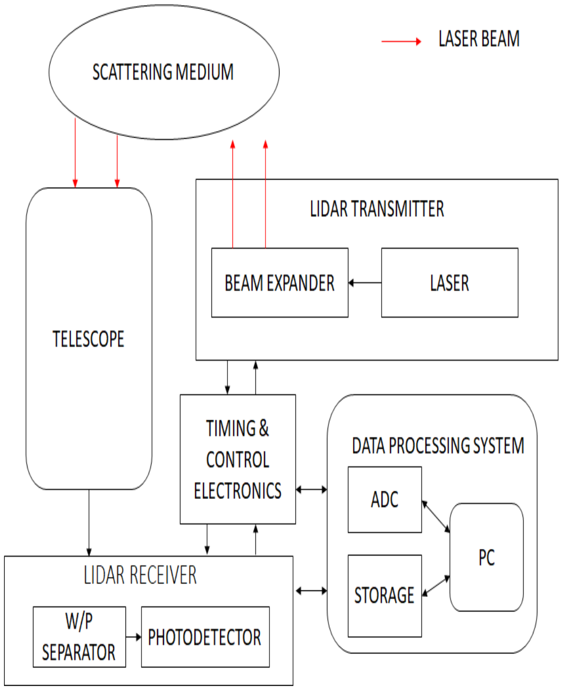


Fig.5 Block Diagram of Lidar system

The main principle behind the working of lidar technology is based on Time of Flight. According to this principle the laser source at the lidar transmitter transmits the laser in the form of pulse into the scattering medium to the object and the reflected or the scattered light from the object is being received by the photodetector at the lidar receiver side where the timing between the transmitted pulse and the received pulse is measured. Photodetector senses the electromagnetic pulse and converts the light energy into electrical. By redoing this in succession the system is able to create a complex map of the surrounding it is measuring.

The laser source uses either green light(532nm) or near-infrared light(1064nm) because these lights are reflected or absorbed by the object properly and helps to determine the precise image of the object and its color.

A Newtonian telescope is also present ahead of the receiver to converge the scattered light coming with different angles from the object so that it can be properly detected by the detector.

As the airborne system is moving and scanning the surroundings, the height and the orientation of the system must be considered while sending the laser pulse and receiving it back in order to determine the exact position of the objects present in the surrounding. To collect this crucial information Position and Orientation system (POS) is used which consists of a Global Positioning System (GPS) to track down the x, y, z location of the airborne system. The GPS allowed us to figure out where lidar reflections are on the ground. POS also includes Inertial measurement unit (IMU) used to track the tilt of the airborne system in the sky which is important for the accurate elevation calculations.

Timing and Control Electronics is used to measure the time of flight of the laser pulse in order to find out the distance of the object from the ground.

Now if we know the timing difference between the received and the transmitted pulse, we can calculate the distance between object by assuming the speed of the laser pulse as the speed of the light.

Let us say that the total distance of the object from the ground is ‘D’ and the time of flight is ‘T’. We know that the speed of light, $C = 3 * 10^8 m/s)$

$So, D = Speedofthelight * timeofflight/2$

$D = 3 * 10^8 * T/2$

All the information collected by the Lidar while scanning the surrounding is recorded in the Data Processing System which includes Analog to Digital Converter (ADC), storage unit and a Computer. ADC converts the information in the analog form to the digital form which is then stored by the storage unit and displayed on the computer.

### C. Flowchart

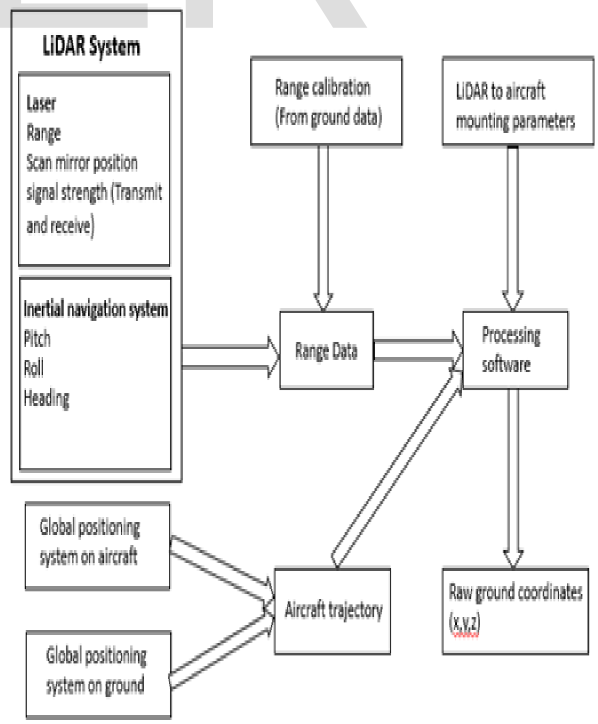


Fig.6 System Flowchart

## V. Result

Fig.7 Scenario to be mapped

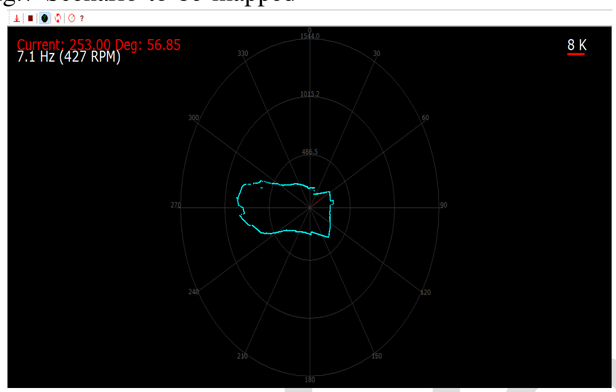


Fig.8 Scanned Scenario

| NUMBER | ANGLE(Deg) | DISTANCE(mm) |
|---|---|---|
| 1 | 0.1868 | 174 |
| 2 | 24.0436 | 131 |
| 3 | 48.4058 | 191 |
| 4 | 72.2296 | 259 |
| 5 | 96.7017 | 246 |
| 6 | 150.9027 | 295 |
| 7 | 200.8246 | 243 |
| 8 | 250.1532 | 640 |
| 9 | 304.2169 | 362 |
| 10 | 359.3738 | 174 |

Table 1 Data obtained from Lidar Scanning

The lidar has a transmitter that sends out 8000 light pulses per minute to scan a 360 degree scenario. Then a receiver captures the reflected light pulses from the surfaces of the obstacle.These reflected pulses are helpful in identifying the distance between the Lidar and obstacle using Doppler formulae.The GUI developed by us captures and computes all the data using a data processing chip to show an approximate mapping of the created scenario as illustrated in Fig.7,8. Table.1 gives the angle and the corresponding distance measured at that particular angle thus compiling all the data to give an approximate image.With an accuracy of 80 percent the lidar and GUI combined can map any scenario to maneuver the drone into tight spaces controlled by a pilot.This decrease in accuracy is due to the interference created by the outdoor light.

## VI. Application

Mapping using Drones are becoming an integral part of many small scale applications nowadays like Defense, Land surveying, Agriculture, Forestry, Construction etc

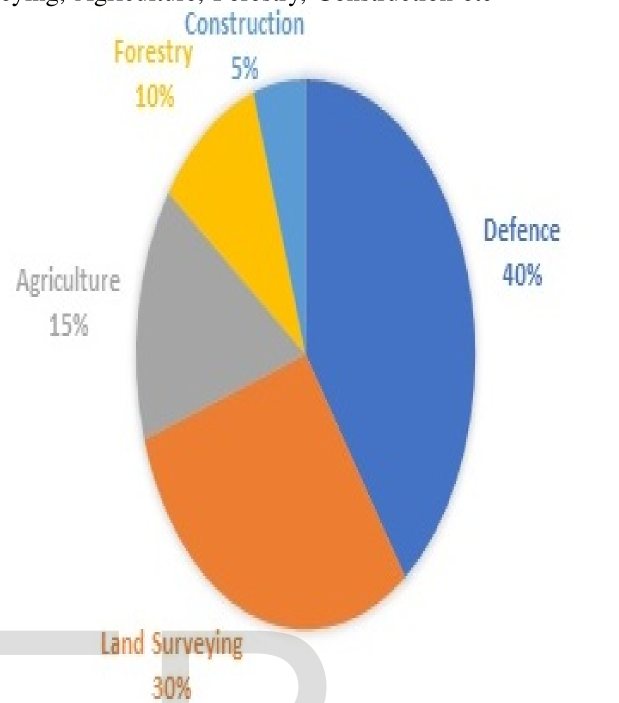




Fig.7 Significance chart of implementing terrain mapping in drones for different applications.

## VII. Conclusion

The landing and accessibility of drones are crucial in such areas where human surveying is difficult and hence this technology assists these drones for a safe and collision free take-offs and landings on rough terrains. LiDAR is common and environmentally friendly. Airborne LiDAR can be flown over territories where access is constrained, incomprehensible or bothersome. It offers critical cost decreases over customary overview techniques.

The future works of this project may be extended to a scale such that there can be more cost effective and efficient methods that can be used for the terrain mapping technology and they can be made available to the public at compelling rates that would benefit future drone pilots, aerial navigators and aerial surveillances etc.

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