International Journal of Advanced Technology & Engineering Research (IJATER)
www.ijater.com

3D MAPPING USING LIDAR IN ROS

Srinivas Peri[1], Tejaswini Kallakuri[2], Shruti Bhargava Choubey[3]

[1,2]Department of Electronics and Communication Engineering, Sreenidhi Institute of Science and Technology, 501301, Telangana, India

[3] Associate Professor, Department of Electronics and Communication Engineering, Sreenidhi Institute of Science and Technology, 501301, Telangana, India

[1]raghuhanuma@gmail.com
[2]ktejaswini369@gmail.com
[3]shrutibhargava@sreenidhi.edu.in

Abstract – LIDAR (light detection and ranging) these sensors are now getting more close to common men these were first introduced in 1960's for detection of submarines by aircrafts and ships to detect ground objects distance and now they came way ahead and are now at our door step they are highly being used in mobile automation industry and for home automation there are two kinds of lidar's 2D and 3D .The 2D lidar's are used to get planer maps where in 3D lidar's are used for three dimensional mapping of objects and obstacle avoidance by modern self-driving cars .These lidar's are also used by drones to collect the aerial views.

I. INTRODUCTION

Nowadays, the environmental research is hard to imagine without the use of remote-sensing techniques like Light Detection and Ranging (LIDAR) and Radio wave Detection and Ranging (RADAR). High spatial and progressive resolution of the measurements, the possibility of observing the atmosphere at ambient conditions, and the potential of covering the height range from the ground to more than 100 km altitude make up the attractiveness of LIDAR instruments.

The variety of interaction processes of the emitted radiation with the atmospheric elements can be used in the LIDAR to allow the determination of the basic environment variables of state, i.e., temperature, pressure, humidity, and wind, as well as the geographical survey, river bed elevation, study of the mines, density of forests and hills, study on underneath of the sea (Bathymetry).

II. HOW DOES LIDAR WORK

The working principle of Light Detection and Ranging system is really quite simple. A LIDAR sensor mounted on an aircraft or helicopter. It generates Laser pulse train, which sent to the surface/target to measure the time and it takes to return to its source. The actual calculation for measuring how far a returning light photon has traveled to and from an object is calculated by

Distance = (Speed of Light x Time of Flight) / 2

Accurate distances are then calculated to the points on the ground and elevations can be determined along with the ground surface buildings, roads, and vegetation can be recorded. These elevations are combined with digital aerial photography to produce a digital elevation model of the earth.The laser instrument fires rapid pulses of laser light at a surface, some at up to 150,000 pulses per second. A sensor on the instrument measures the amount of time takes for each pulse to reflect back. Light moves at a constant and known speed so the LIDAR instrument can calculate the distance between itself and the target with high accuracy. By repeating this in quick progression the instrument builds up a complex 'map' of the surface it is measuring.

With **airborne Light Detection and Ranging**, other data must be collected to ensure accuracy. As the sensor is moving height, location and orientation of the instrument must be included to determine the position of the laser pulse at the time of sending and the time of return. This extra information is crucial to the data's integrity. With **ground-based Light Detection and Ranging** a single GPS location can be added at each location where the instrument is set up.

a) *TYPES OF LIDAR SYSTEMS –*

b) *Based on the Platform*

- Ground-based LIDAR
- Airborne LIDAR
- Space borne LIDAR

figure i.Ground based lidar

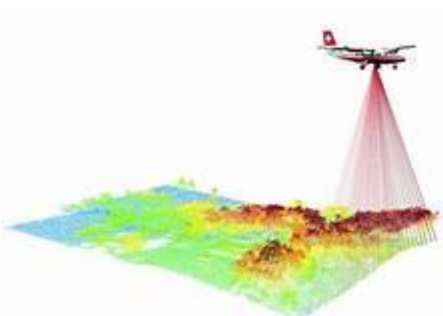

Figure ii. Air borne lidar

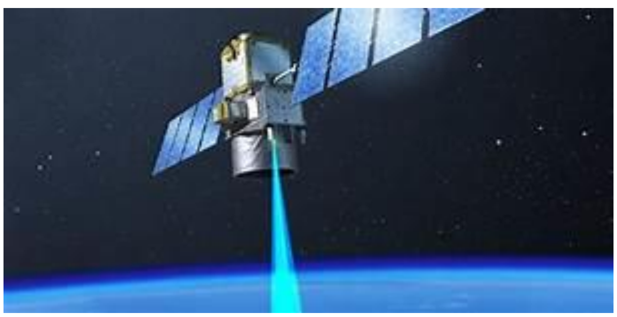

Figure iii. Space borne lidar

c) Based on Physical Process

- Rangefinder LIDAR
- DIAL LIDAR
- Doppler LIDAR

Figure iv. Rangefinder lidar

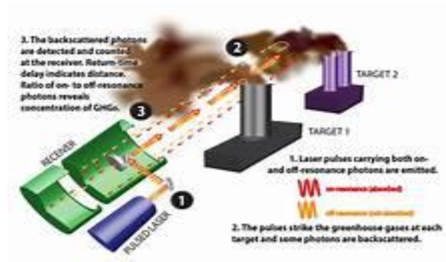

Figure v. Dial lidar (differential absorption lidar)

Figure vi. Doppler lidar

d) Based on Scattering Process

- Mie
- Rayleigh
- Raman
- Fluorescence

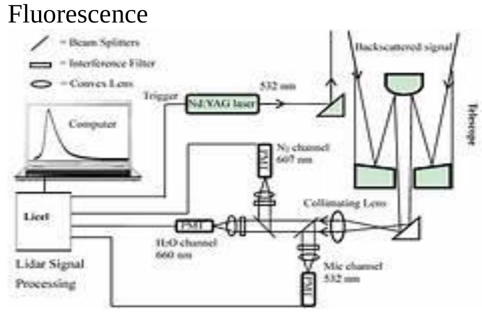

Figure vii. MIE scattering

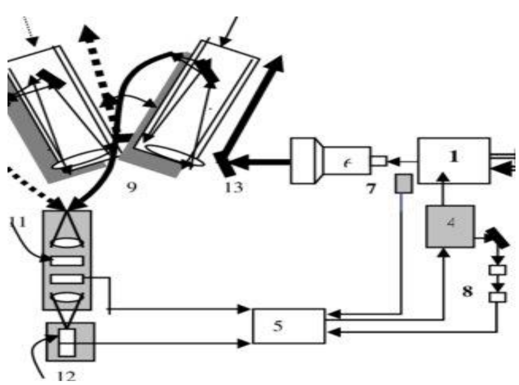

Figure vii. Rayleigh scattering

III. MAIN COMPONENTS OF LIDAR SYSTEMS

Most Light Detection and Ranging systems use four main components

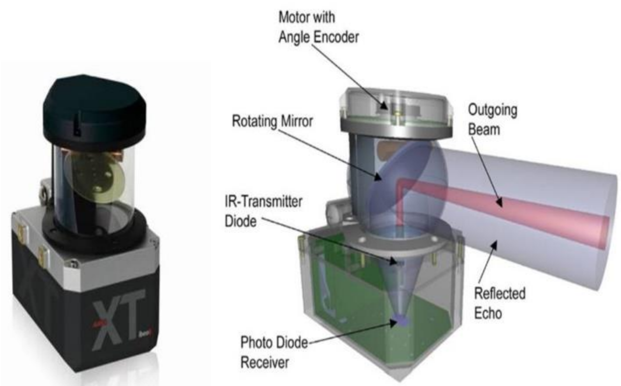

Figure viii. Internal Composition of Lidar

e) Lasers

The Lasers are categorized by their wavelength. Airborne Light Detection and Ranging systems use 1064nm diode-pumped Nd: YAG lasers whereas Bathymetric systems use 532nm double diode-pumped Nd: YAG lasers which penetrate into the water with less attenuation than the airborne system (1064nm). Better resolution can be attained with shorter pulses provided the receiver detector and electronics have sufficient bandwidth to manage the increased data flow.

f) Scanners and Optics

The speed at which images can be developed is affected by the speed at which it can be scanned into the system. A variety of scanning methods is available for different resolutions such as azimuth and elevation, dual axis scanner, dual oscillating plane mirrors, and polygonal mirrors. The type of optic determines the range and resolution that can be detected by a system.

g) Photodetector And Receiver Electronics

The photo detector is a device that reads and records the backscattered signal to the system. There are two main types of photodetector technologies, solid state detectors, such as silicon avalanche photodiodes and photomultipliers.

h) Navigation And Positioning Systems/GPS

When a Light Detection and Ranging sensor is mounted on an aeroplane satellite or automobiles, it is necessary to determine the absolute position and the orientation of the sensor to maintain useable data. Global Positioning Systems (GPS) provide accurate geographical information regarding the position of the sensor and an Inertial Measurement Unit (IMU) records the accurate orientation of the sensor at that location. These two devices provide the method for translating sensor data into static points for use in a variety of systems.

2) LIDAR Data Processing

The Light Detection and Ranging mechanism just collect elevation data and along with the data of Inertial Measuring Unit is placed with the aircraft and a GPS unit. With the help of these systems the Light Detection And Ranging sensor collect data points, the location of the data is recorded along with the GPS sensor. Data is required to process the return time for each pulse scattered back to the sensor and calculate the variable distances from the sensor, or changes in land cover surfaces. After the survey, the data are downloaded and processed using specially designed computer software (LIDAR point Cloud Data Processing Software). The final output is accurate, geographically registered longitude (X), latitude (Y), and elevation (Z) for every data point. The LIDAR mapping data are composed of elevation measurements of the surface and are attained through aerial topographic surveys. The file format used to capture and store LIDAR data is a simple text file. By using elevation points data may be used to create detailed topographic maps. With these data points even they also allow the generation of a digital elevation model of the ground surface.

3) Applications of LIDAR Systems

a) Oceanography

The LIDAR is used for calculation of phytoplankton fluorescence and biomass in the ocean surface. It is also used to measure the depth of the ocean (bathymetry).

b) DEM (Digital Elevation Model)

It has x, y, z coordinates. Elevation values can be used everywhere, in roads, building, bridge and other. It has made easy to capture the surface height, length, and width.

c) Meteorology

LIDAR has been used for the study of the cloud and its behavior. LIDAR uses its wavelength to strike small particles in the cloud to understand cloud density.

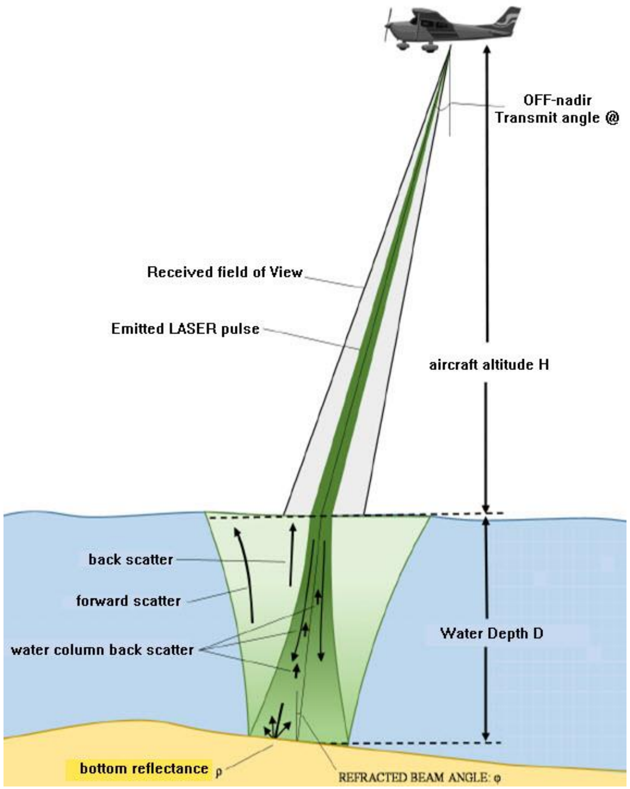

Figure ix. Lidar used in oceanography

d) Atmospheric Physics

LIDAR is used to measure the density of clouds and concentration of oxygen, Co2, nitrogen, sulfur and other gas particles in the middle and upper atmosphere.

e) Military

LIDAR has always been used by the military people to understand the border surrounding land. It creates a high-resolution map for the military purpose.

f) River Survey

Greenlight (532 nm) Lasar of the LIDAR is used to measure underwater information is required to understand the depth, width of the river, flow strength and more. For the river engineering, its cross-section data are extracted from Light Detection And Ranging data (DEM) to create a river model, which will create a flood fringe map.

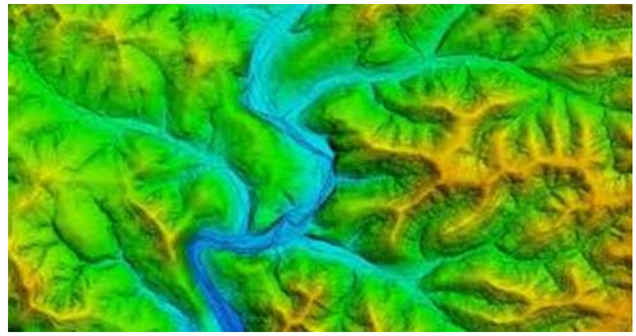

Figure x. Lidar generated river scan images

g) Micro-Topography

Light Detection And Ranging is very accurate and clear-cut technology, which uses Laser pulse to strike the object. Regular Photogrammetry or other survey technology cannot give the surface elevation value of forest canopy. But the LIDAR can penetrate through the object and detect the surface value.

IV. LIVOX MID-40

Of all the 3D lidars available in the market, the most commercially affordable is Livox Mid-40. It is designed by DJI, a company famous for manufacturing user friendly drones and its components. The Livox Mid-40 has an FOV(field of view) of 38.4 degrees in horizontal and vertical axes. It can scan upto a range of 260 meters.

Figure. Livox mid-40

The laser in the Livox Mid-40 follows Risley scanning pattern. A pictorial representation of the scan pattern is provided below.

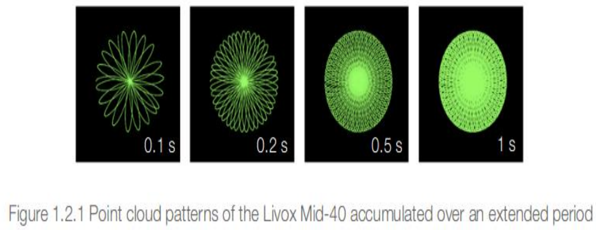

Figure. Scan pattern of livox mid-40

In this concept, we used the open source code made available in github by students of hong-kong university by the name loam-livox. LOAM stands for Lidar Odometry And Mapping. The stitching of the 360 degree map view can be accomplished in three different ways:

i. Using aft_mapp.pcd files generated by using loam_livox, and converting them into importable formats like .ply or .las, in ROS

ii. Using IMU sensor attached to the lidar, which is compatible with livox mid-40

iii. Using a GPS or GNSS module connected to the livox mid-40

The cheapest way of these three and perhaps the easiest way of obtaining a full-fledged 3D map is, by using the loam_livox package inside ROS. The accuracy of the point cloud in the generated scan will depend on the number of iterations of scans the lidar runs.

VI. RESULTS

After assembling the required software and hardware components, testing the capabilities of the lidar in outside environments, the following scans are generated and saved. These scans are in .pcd file format which stands for Point Cloud Data. These files can be converted into other formats as required, for example into .ply (Polygon file format) or .las file format. The then generated files can be viewed, edited and formatted on different softwares like MeshLab or Unity. The output from those softwares can be pushed into applications that give us a 3D experience of the scans recorded by the lidar.

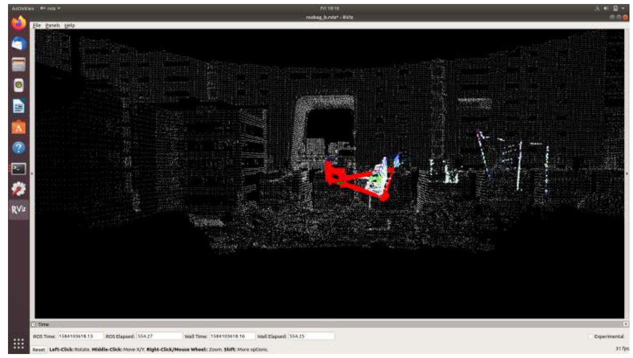

Figure. 3D scan generated by livox mid-40

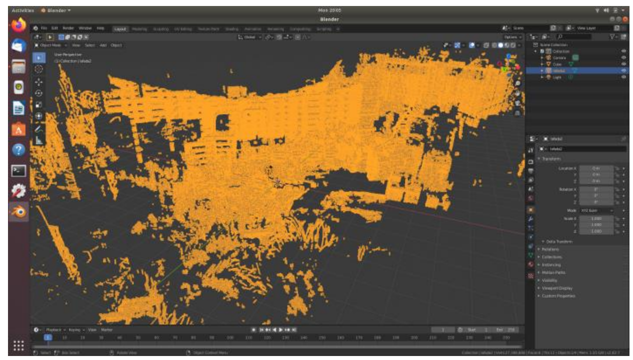

Figure. 360 degree view of 3D scan produced by livox mid-40

References:

[1] https://github.com/hku-mars/loam_livox

[2] https://www.livoxtech.com/mid-40-and-mid-100

[3] https://www.explainthatstuff.com/lidar.html