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Real World Scanning and 3d Modeling Using LiDAR

Nirmal Mandal[1], Gaurav Raje[2], Varsha Randeve[3], Udit Rikame[4], Prof. Namrata Lade[5]

[1](*Department of Electronics, Atharva College of Engineering, Malad-West, Mumbai-400095,*
[2](*Department of Electronics, Atharva College of Engineering, Malad-West, Mumbai-400095,*
[3](*Department of Electronics, Atharva College of Engineering, Malad-West, Mumbai-400095,*
[4](*Department of Electronics, Atharva College of Engineering, Malad-West, Mumbai-400095,*
[4](*Department of Electronics, Atharva College of Engineering, Malad-West, Mumbai-400095,*

Abstract: *Ever since the computer graphics came in existence, we have been using various techniques to create 3D models and animations of different objects. In engineering fields these 3D modeling techniques play vital roles, whether it's creating software model of cars in automobiles or floor planning in architecture. Our project is also based on same idea of creating 3D models by scanning real world object using LiDAR.LiDAR- Light Detection and Ranging uses laser pulses to scan a particular area in 360 degrees. We are going to use two motors to move LiDAR sensor in desired direction. LiDAR data, called as point cloud, then will be processed in the Processing 3D software(version 3) to render 3D models. The portability of device will allow us to attach it to other devices such as drones and RC cars.*

Key words: *LiDAR, Processing 3D, TOF, manipulation, TFMini.*

I. Introduction

LiDAR stands for Light Detection and Ranging.It is a remote sensing method that uses light in the form of a pulsed laser to measure distances. These light pulses combined with other data recorded by the airborne system generate precise, three-dimensional information about the shape of the object and its characteristics. LiDAR consists of a transmitter which illuminates a target with a laser beam, and a receiver capable of detecting the component of light which is essentially coaxial with the transmitted beam. Receiver calculates a distance, based on the time needed for the light to reach the target and travel back.

The collected information is only about the distance of an object from LiDAR sensor. But the real life, area is three dimensional and can only be precisely rendered if we convert the linear data into spherical form. LiDAR scan takes the spherical coordinates (R, ω, α) as the reporting coordinates, if the decoded information needs to be constructed into a point cloud, it must be converted into a three-dimensional coordinate system[1].

The first major task was to accurately scan map the real world places, objects, etc. For this we have used LiDAR. The principle of LiDAR is similar to Electronic Distance Measuring Instrument (EDMI), where a laser (pulse or continuous wave) is fired from a transmitter and the reflected energy is captured. To move the LiDAR in desired position, we have used two motors.

Based on this collected data a 3D model can be generated using Processing 3D software. We are using the third version of processing 3D which is open source software.

II. Literature Review

In past two decades Airborne Light Detection and Ranging (LiDAR) has become a key source of high resolution, three dimensional, remote sensed data for understanding Earth surface mechanics and studying land cover and its changes. The LiDAR data are typically used as complementary information to passive multispectral or hyper spectral imagery to obtain higher level cover classification accuracy[2].

LiDAR data could be airborne (data collected using airplanes), spaceborne (collected using satellites) or terrestrial (collected form the ground). More so, ground based LiDAR data can either be static or mobile. In Mobile

Laser Scanning (MLS) scanning equipment is mounted on vehicles, which travel along the highway of interest capturing 360˚ imagery of the roadway. MLS is the most common approach to collect data for transportation applications since road features can be captured with a high level of detail. Mobile LiDARs typically are mounted on a vehicle or vessel for environmental scanning. The measure can be run day and night and efficiently capture millions of 3D point cloud information per minute that widely used in autopilot systems and environment recognition [1][4].

Forest vertical structure parameters are one of critical components for understanding of the global forest carbon storage and cycle, as well as climate changes. Polarimetric SAR Interferometry (Pol-In-SAR) techniques and waveform LiDAR have been widely and successfully used for extracting 3D forest structure profiles by means of both SAR and LiDAR airborne systems, but individually[3].

Forest plays an important role in ecosystem with vast vegetation species and maintains the balance of global carbon exchange. The accurate estimation of forest height is very important for understanding forest biomass and forest vertical structures. It is very challenging to characterize the complexity of forest, especially for large areas. Recent development of UAV LiDAR technology, as an alternative remote sensing platform, could capture relative high quality data at much lower cost[6].

Detecting and recognizing underwater objects is a topic of great interest in many maritime applications, such as harbour security, safe navigation of autonomous underwater vehicles, and safety of the littoral zone. Fluorescence Light Detection and Ranging (LiDAR) systems play an important role in this context[5].

III. Proposed Method

LiDAR is just like RADAR but uses laser pulses to scan an area. This data is then used to make 3D models of that area. The sensor we are using will only get us the information about the distance of an object from LiDAR source. But to create 3D model we require information about the depth, height, angle etc. So there must be some way to collect this information.

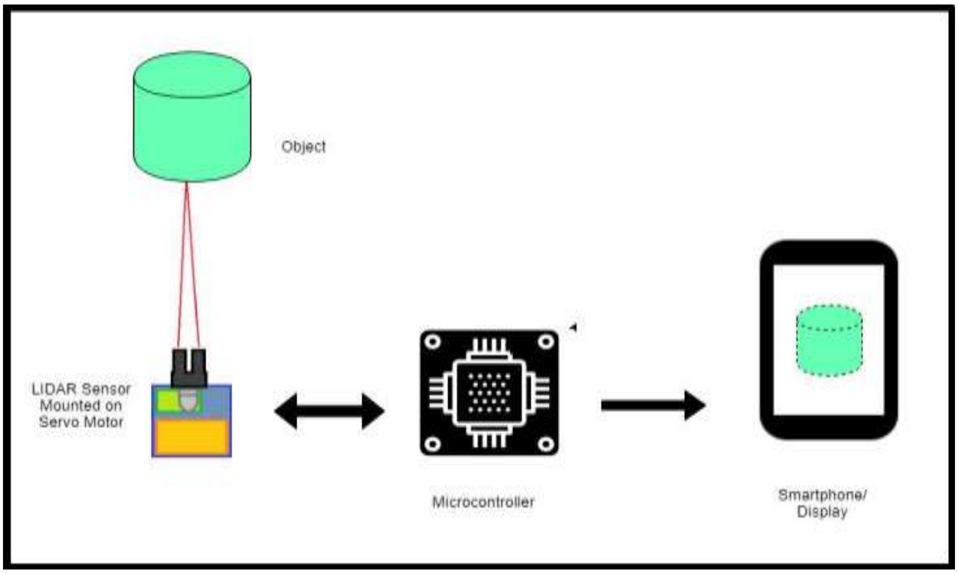

Fig.1. *Block Diagram of LiDAR Scanner.*

We came up with an idea of using servo motors to rotate the LiDAR sensor to get data in angular manner. A combination of two servo motors will be used to get control of azimuth (horizontal) and elevation(vertical) movements. Both the motors will be controlled using a servo controller along with a microcontroller. This will enable us to collect information that we want but yet this information is not in spherical format which is essential to perform 3D rendering. So using algorithms in coding we can express this linear and angular form of data into spherical format.

After the collection of required data the task will be to process it and it will be done using open source Processing software (version 3).

We are planning to do interfacing with android devices to easily interact with 3D model via touchscreen displays. The device will be made portable in order to use with other devices such as drones and RC cars. This will add up in its versatility.

IV. Components

This project makes use of following listed components:

- TFMini- micro LiDAR module (main sensor)
- Arduino Uno (microcontroller)
- SG90 servo motors
- Processing 3D Software(version 3).

Fig.2. *TFMini – Micro LiDAR sensor*

Primarily we built a prototype by using a TOF sensor – VL53LOX. We were able to produce point clouds from this sensor but the rendering results were not good.

But the TFmini sensor is much more capable and has range of up to 12 meters whereas the vl53lox had only 1 meter range. Also the TFmini uses lenses with the laser source so the scattering of laser pulses is much lesser than vl53lox, which has no lens in it.

V. Data Manipulation for 3D Model Rendering

As stated earlier, the LiDAR data will be only regarding the distance of an object from sensor. That means we cannot represent the position of a point in space only with single parameter (distance). Hence we need to get more information about the object.

We can get linear distance data from LiDAR sensor and two angles form rotation of motors. So we will be getting (R, ω, α). R- distance, ω - elevation andα - azimuth. These are the Spherical coordinates, to convert them into Cartesian coordinates; we will use following conversion formulas.

Hence to convert (R, ω, α) to (X, Y, Z)-

$$X= R*\sin(\omega)*\cos(\alpha)$$
$$Y= R*\sin(\omega)*\sin(\alpha)$$
$$Z= R*\cos(\omega)$$

Before applying this formula, the angles will be converted from degree to radians with the following formula-

$$\text{Angle in radian} = \text{angle in degree} * \frac{\pi}{180}$$

Above mentioned manipulation is necessary for 3D rendering. This manipulation will be done in the programming.

II. Advantages

The advantages of this project are as follows:

- The area to be scanned can be adjusted as per requirement.
- Portability: we can attach this device on other devices for advance operations.
- Precision can be adjusted as per requirement.
- Can be used day and night: LiDAR technology can be used day and night thanks to the active illumination sensor.
- It can be integrated with other data sources: LiDAR technology is a versatile technology that can be integrated with other data sources which makes it easier to analyze complex data automatically.
- Human dependency is minimum: LiDAR technology, unlike photogrammetry & surveying has minimum human dependence since most of the processes are automated. As well as it ensures valuable time is saved especially during the data collection & data analysis phase.
- It is cheaper than other remote sensing methods available.

VI. Limitations

There are some limitations of LiDAR which are listed below:

- High operating costs in some applications: Although LiDAR is cheap when used in huge applications; it can be expensive when applied in smaller areas when collecting data.
- Laser pulses reflected from shiny mirror like surfaces produce false information. This can be overcome by machine learning.
- Ineffective during heavy rain or low hanging clouds: LiDAR pulses may be affected by heavy rains or low hanging clouds because of the effects of refraction. However the data collected can still be used for analysis.
- Unreliable for water depth and turbulent breaking waves: When it is used on water surfaces or where the surface is not uniform, it may not return accurate data since high water depth will have adverse effects on the reflection of the pulses.
- The laser beams may affect human eye in cases where the beam is powerful: The Laser beams used by LiDAR pulses are usually powerful in some instances and these may affect the human eye.
- Low operating altitude of between 500-2000m: LiDAR technology cannot work on altitudes higher than 2000 meters because the pulses will not be effective at these heights.

VII. Applications

Following are some of the advance uses and applications of LiDAR technology:

- Security: This device can be mounted on any surveillance vehicles such as drone, RC cars etc. It can be used for scanning and mapping terrorist prone area, Remote Sensitive area, restricted area,etc.
- VR Environment Development: A virtual environment can be developed for gaming, CGI Film, Simulation Training,etc. with the help of real world mapping.
- Architectural engineering: For Interior designing and generating dummy model.
- Mining: For scanning poisonous mines, to calculate depth of mines,etc.
- LiDAR technology is able to tell which species of birds are available in the forest. This is mostly done through the analysis of the type and species of trees that exist in a forest because these are what determine the type of birds that will exist in there.
- LiDAR technology is one of the most common technologies used in the field of mapping. LiDAR has the ability to collect accurate data at a faster rate and give the exact map of a given area. LiDAR also can generate 3D maps of an area such as a forest or a river with the exact dimensions.
- Road mapping and road planning is one of the most common uses of LiDAR technology. Transport industry relies on LiDAR technology to map thestructures of the road. It helps them in determining the lengths of the roads against the structure of the terrain.
- LiDAR technology is used in gaming in recreating the exact environment in games. For instance, in a track game, the laser pulses from LiDAR will be used to capture the exact color scheme and structure of the track and then fed into the computer to create the race track.
- The autonomous vehicle industry has beenaffected more from LiDAR than any other industry. The number of autonomous vehicles using LiDAR is rising day by day. These vehicles are also getting better at obstacle detection and avoidance due to advancements in the LiDAR technology.
- LiDAR has several uses in the military. The military uses LiDAR technology to map out the exact terrain of the battlefield and know the exact position of the enemy forces.
- 3D imaging is one of the best and most common uses of LiDAR technology. LiDAR has been used by various researchers to get 3D images of an area which represents the precise map or image of the object being mapped.
- LiDAR is used in the survey of the urban structure and planning. The technology is used to map out the exact points within an area and tell exactly where all the points are located.

VIII. Conclusion

LiDAR is very versatile technology which can be used along with other technologies like GPS. The applications of LiDAR are limitless. Due to the basic principle of operation of LiDAR, it is available in many different forms of sensors for various kinds of purposes.

With our project, we will be exploring depths of 3D modeling and LiDAR technology.

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