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LiDAR for Object Detection in Self Driving Cars

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ABSTRACT- Self driving cars are the major invention in vehicular automation. These cars use sensors to perceive the surrounding and control accordingly. Object detection becomes a major task in these driverless cars. In this study, utilization of LiDAR to automatically control speed, braking, and safety systems in response to sudden changes in traffic conditions is presented. The aim of this study is to do precise and quick object detection for LiDAR based self-driving cars. This work proposes image processing to be used to identify and differentiate similar looking objects so that carefully calculated driving decisions can be taken.

KEYWORDS- Autonomous Self-driving, Driverless, LiDAR, Object classification, Object detection

I. INTRODUCTION

A self-driving car is capable of travelling without human intervention. It is sometimes referred to as a robotic car, driverless car, or autonomous car. These vehicles sense their environment using sensors. Control systems analyze sensory data to build a three-dimensional representation of the environment around the vehicle. The vehicle then determines a suitable navigation route based on the model as well as approaches for navigating traffic restrictions (such as stop signs) and barriers [1] [2].

These autonomous vehicles are expected to have an impact on the auto business, as well as the health, welfare, urban planning, traffic, insurance, labor market, and other industries once the technology is more developed. However, it may face few technological obstacles as under:

- In tumultuous inner-city settings, artificial intelligence is still unable to perform as intended.
- A car's computer could potentially be compromised, as could a communication system between cars.
- The ability to avoid large animals requires recognition and tracking, and Volvo found that software designed for caribou, deer, and elk was ineffective with kangaroos. The susceptibility of the car's sensing and navigation systems to different types of weather (such as snow) or deliberate interference, including jamming and spoofing. They would need to be able to revert to sensible behaviors in situations where these maps might be outdated.
- Competition for the desired radio spectrum for communications in cars.
- Field programmability for the systems will require careful evaluation of product development and the component supply chain.
- For automated cars to operate at their best, the current road infrastructure may need to be modified.
- Validation challenge of Automated Driving and need for novel simulation-based approaches comprising digital twins and agent-based traffic simulation [2] [3].
- In addition to these, precise object detection becomes a crucial task for relying on these cars.
- There are many ways to gather the information from surrounding to detect an object such as such as optical and thermo-graphic cameras, radar, LiDAR, ultrasound/ sonar, GPS, odometry and inertial measurement units. Among these LiDAR is a promising and precise technology that can be utilized for object detection.

II. TRACKING METHODS

For autonomous driving to be accurate and effective, object tracking is crucial. The identification of things from photographs and vehicle sensor data, such as pedestrians, autos, and other obstacles, is a crucial and challenging interdisciplinary field. It incorporates contributions from machine learning, signal processing, and/or computer vision. The majority of processed sensor data comes in the form of point clouds, pictures, or a combination of the two. There are several ways to manage point cloud data, but the most popular one is some kind of 3D grid where a voxel engine is used to navigate the point space. When numerous forms of sensor data are available, registration, point matching, and image/point cloud fusion may be necessary. The need to take into consideration temporal cues and estimate motion from time-based frames makes this task more challenging [4] [5].

Rarely does a single target appear in the scenes involved in autonomous driving scenarios. The majority of the time, several items must be simultaneously detected and tracked, some of which may be moving with respect to the vehicle and to other objects. As such, most approaches in the related literature handle more than one object and are therefore aimed at solving multiple object tracking problems (MOT) [5].

A sequence of sensor data is available from one or multiple vehicle-mounted acquisitions devices. Most related methods involve assigning an ID or identifying a response for all objects detected within a frame, and then attempting to match the IDs across subsequent frames. Given that the monitored objects may enter and exit the frame at various timestamps, this is frequently a challenging process. They might also be blocked from view by their surroundings or even by one another. Additional problems may be caused

by defects in the acquired images: noise, sampling or compression artifacts, aliasing, or acquisition errors [4] [5].
The most prevalent need for automatic driving object monitoring is real-time video. Thus, in addition to individual object recognition, the goal is to link monitored objects across numerous video frames. Additional difficulties arise when accounting for variations in motion, such as when objects are subject to rotation or scaling transformations or when their relative movement speeds are fast [5].
Images are typically the primary mode for interpreting the scene. As a result, 2D MOT is the focus of many efforts in the associated literature. These techniques rely on a series of detection and tracking phases, in which successive detections that have the same classification are connected to establish trajectories. The inherent existence of noise in the captured photos poses a substantial difficulty because it may negatively alter the attributes of identical objects across consecutive frames. Therefore, computing robust features is a crucial component of object detection. Color, frequency and distribution, shape, geometry, contours, or relationships within segmented objects are just a few examples of the many different object qualities that features might represent. The most widely used feature detection techniques nowadays use supervised learning. Machine learning algorithms are used to gradually refine features, which initially start off as collections of random numbers. Such methods call for the careful selection of hyper-parameters and the use of appropriate training data, frequently discovered through trial and error. The best results, however, in terms of accuracy and robustness to affine transformations, occlusion, and noise are provided by supervised classification and regression approaches, according to a number of findings from the associated literature [5].

III. PROPOSED METHOD

LiDAR combined with image processing can give precise results for object detection. Further it can be combined with speed-distance measurements so that the control system can take decisions accordingly [6].
The term "light detection and ranging," or LiDAR, is frequently used to refer to a type of sonar that employs pulsed laser beams to measure the distance to nearby objects. As LiDAR systems have shrunk in size, more uses have emerged that make use of the technology's adaptability, accuracy, and record-breakingly quick data collection. Most notably, carmakers are leveraging LiDAR capabilities as a key component in their race to develop safe, self-driving vehicles [7] [8].
Both ADAS (Advanced Driver Assistance Systems) and autonomous vehicles use LiDAR because its sensors enable accurate, trustworthy navigation during real-time autonomous operation on highways and in urban areas. In order to help vehicles safely move at varied speeds, they can identify and track other vehicles, pedestrians, and other objects. This includes traveling night and day in a range of road conditions such as rain, sleet, and snow. However, it can’t differentiate between a plastic bag and an obstacle; a cyclist giving hand signal to change lane or a rod projecting out from a pillar and many more which may affect the control of autonomous cars. This raises the need for a precise object detection based on inputs obtained from LiDAR sensors so that similar appearing objects can be differentiated [9] [10].
To overcome these issues, object detection techniques of image processing can be combined with LiDAR based autonomous cars in such a way that different cloud points obtained from these sensors are clustered together to form a recognizable shape as shown in figure 1.

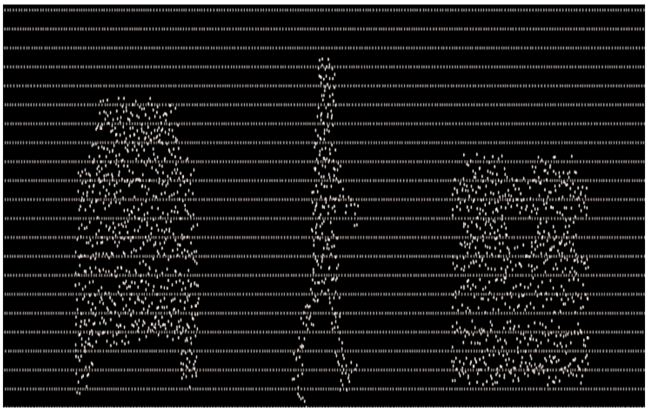

Figure 1: Clustering of Cloud Points [10]

Thereafter, image classification techniques are used to identify these shapes as objects as shown in figure 2.

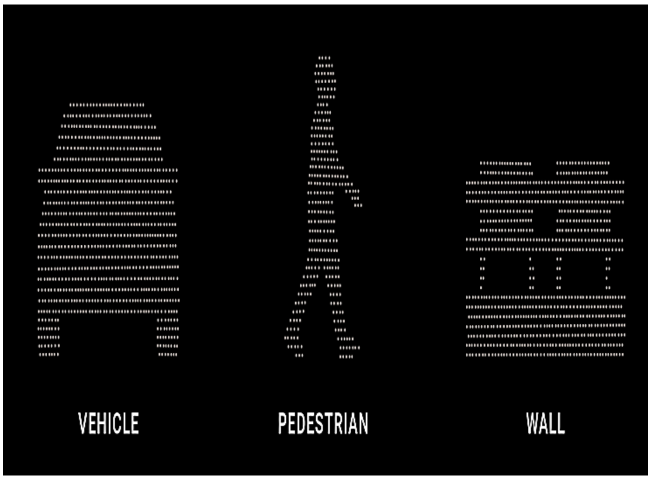

Figure 2: Classification of Shapes formed [11]

Thereafter modeling of classified objects is done to predict all possible movements with speed as shown in figure 3.

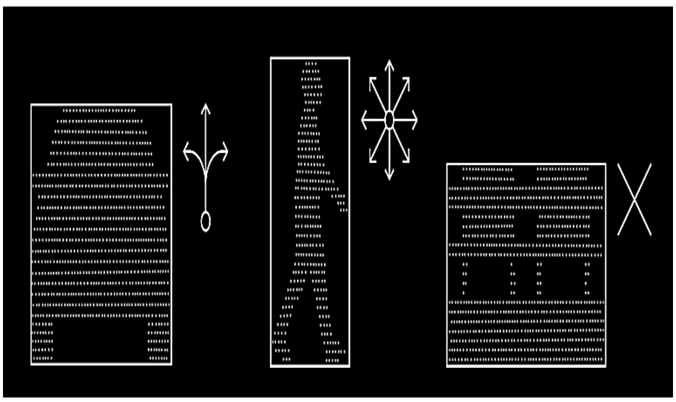

Figure 3: Modeling of Classified Objects [11]

IV. OBJECT CLASSIFICATION

Finding objects in point cloud data is the initial step in recognizing and classifying them using a variety of techniques and algorithms. After converting raw data into a point cloud structure, one of the first steps is the point clustering or segmentation, which basically consists in grouping points based on common characteristics. After this step, redundant data can be removed from the point cloud, resulting in less data to be transferred and processed in the upcoming phases. Some methods begin by categorizing the point cloud into background and foreground data in applications where the sensor maintains a stationary position. Because they don't depict dynamic objects, points that are in the same place in several frames are disregarded as backdrop. For the remaining points (foreground), the distance between points is measured, and points close to each other are clustered and marked with a bounding box as they possibly represent an object. However, when the sensor moves with the car, these approaches are not effective, as the background and objects move together inside the point cloud. Therefore, automotive approaches require robust and faster algorithms since the objects in the point cloud also change at higher frequencies. Initial approaches used sliding windows algorithms with Support Vector Machine (SVM) classifiers and hand-crafted features for object detection, but were quickly replaced by newer superior techniques such as 2D representations, volumetric-based, and raw point-based data, which deploy machine learning techniques in the perception system of the vehicle .These classification /object detection results along with LiDAR based distance and speed measurements can help in a more accurate control of self-driving cars[12][13][14].

V. CONCLUSION

Autonomous cars are a big milestone in automation of vehicles. Cars with advanced driver assistance that provide numerous features such as cruise control are already there in market which aids in comfortable driving. However, switching to autonomous cars is still far ahead because of its technological challenges. LiDAR combined with suitable algorithm for object classification technique can be a potential approach for object detection.

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