DOI: 10.54254/2755-2721/142/2025.KL21566

The Environmental Perception of LiDAR in Electric Vehicles

Hongyi Wang[1,a,*]

[1]*Electromechanical and Vehicle Academy, East China Jiao Tong University, Nanchang, Jiangxi, 330013, China*

a. 17276094152@163.com

**corresponding author*

Abstract: With the popularization of the Intelligent driving, new energy vehicles have gradually replaced the traditional fuel cars. The environmental perception of light detection and ranging (LiDAR) in intelligent driving is the vital safeguard of drivers and vehicles themselves. Nowadays, LiDAR has been widely applied in the field of unmanned driving, which receives the information of surroundings through reflected Laser beam sent by its emitters. This article analyses the meanings and uses of LiDAR through the point cloud detection technology, combining with the application cases of LiDAR in electric vehicles. This paper finds that the effects of LiDAR are measuring the distance of the obstacles from the vehicles and reminding the drivers to pay attention to their driving safety. This technology has critical effects of vehicle security and driving safety. This study promotes the production and utilization of electric vehicles, helping to address the energy and environment issues and making contribution to the LiDAR technology.

Keywords: LiDAR, environmental perception, point cloud survey, electric vehicles

1. Introduction

With the development of global economy and population, the dependence of petroleum among traditional fuel cars has led to the severe trade conflicts of petroleum. Additionally, the waste gas emitted from fuel cars is one of the main air pollution sources, doing serious harm to the environment and human health. The development of electric vehicles can reduce the reliance on petroleum, decreasing the waste gas emission and relieving the energy and environment stress. Rabia Rashdi, et al. compared two kinds of Mobile Laser Scanner (MLS), double-end Lynx Mobile Mapper and single-end VUX-1 HA, with terrestrial laser scanner Faro Focus XX30, using the reference database of Cloud Point Faro Focus XX30 and Global Navigation Satellite System (GNSS) database of Trimble R8 to evaluate the performance of the road in city and half-city. Precision is measured by difference value between Trimble GNSS and MLS coordination. The data processing center compares every geometrical characteristic of light detection and ranging (LiDAR), using a machine learning classifier to survey the road and urban. The results show that the MLS-single-end scanner get satisfied precision in road and halt-city while Faro behaves better in city. This research helps researchers to opt for appropriate mobile laser scanners to draw transportation infrastructure, offering valuable insights in various environments [1]. Soontorn Odngam, et al. came up with a kind of design of braking hydraulic pressure alarms and control systems based on LiDAR control braking hydraulic pressure in academy autonomous vehicles, measuring the preceding obstacles distance. It reveals that alarms and control systems can operate correctly and smoothly, according to the relative conditions in the required distance, which can also be applied to other kinds of vehicles [2]. Mingmao Cai, et al. researched the security of vehicles driving on the vertical curve road on the basis of LiDAR in the harsh climates. The key is a function including the Available Sight Distance (ASD) and Required Stopping Sight Distance (RSD), which uses neural network and Monte Carlo simulations to analyse and evaluate the reliability of LiDAR-based automated vehicles (LAVs) [3].

Based on the above findings, this paper focuses on the environmental perception technology through LiDAR point cloud technology. This paper aims to enrich the theoretical framework of environmental perception and new energy, advancing academic research in related fields.

2. The Theory of Environmental Perception about LiDAR

Environmental perception of LiDAR is based on distance detection theory, mainly by emitting a laser beam and receiving the reflected light. The specific procedure can be divided into 5 steps. The first step is that laser impulse emission. LiDAR is equipped with lasers internally, sending the laser beam according to the specific time and angle, and vast impulse. such as the mechanical, which can send an all-around laser, solid LiDAR, which controls the sending direction through electronic components. The second step is that the laser beam is rejected when contacting with the target obstacle. The partially rejected laser beam returns back to the LiDAR along with the primary path. The third Step is to reject laser beam reception and time measuring. LiDAR receives the rejected laser beam, recording the time difference between laser emission and reception precisely. According to the distance equation, distance is light speed multiplied by time difference divided by two; the target obstacle can be calculated according to the equation [4]. The fourth step is point cloud production. Once measurement can obtain one distance information, with the operation of LiDAR, a massive of Cloud Point is measured, forming the point cloud information. Each point has three-dimension coordinate and reflect strength and other attributes [5]. The fifth step is environmental perception and modeling. Point cloud data is handled by the data processing center, recognizing the target obstacles' shape, size, location and other information, constructing the environment three-dimensional model, helping the automatic drive, and robot navigation to application. When vehicles are driving, LiDAR rotates at a constant rate and sends lasers and collects reflected point information in order to get all-round environment information. LiDAR record the time and level angle [6].

The key technology of LiDAR is point cloud technology, getting target obstacles distance information, forming target obstacles' three-dimensional space through point geometry formation. Specific formula is as follows [4]:

$$L = c \times t \div 2 \tag{1}$$

L is the distance between the vehicle and target obstacles, c is light speed, and t is the time difference between emission and reception.

According to the formation, the distance between the measurement point and LiDAR can be obtained. Combining with the laser scanning angle information simultaneously, the point can be located in the three-dimensional space. The procedure consists of the following steps.

The first step involves data collection, during which LiDAR scans the target obstacles at specific frequencies and angles, resulting in the acquisition of primary point cloud data. The second step is preprocessing, where the data handling center removes noise points to enhance data quality, thereby creating a cleaned point cloud. The third step focuses on characteristic extraction, in which LiDAR identifies geometric features, such as curvature and normal vectors, to facilitate target identification and classification. The final step involves target identification and modeling, where machine learning methods and other algorithms are utilized to identify the obstacles and construct a three-dimensional model [6].

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3. The Utility Case of LiDAR

The wide uses of LiDAR in electric vehicles are as follows.

3.1. Vehicle Quality Production Detection

The Automated Precision Inc (API) is a manufacturer of mechanical and high-precision measuring devices in the US., contributing to the production of precise devices and products to satisfy the rapid growth of industrial technology.

The API 9D LiDAR of API company applies to the production of vehicles, which gather measuring data through capturing the interference information. When lasers come into contact with target obstacles, emission lasers interfere with the reflected laser. The system analyses the characteristics of interference lasers, such as phase difference and frequency, and figures out the obstacles distance and location information. Considering the systems have high sensitivity, 100 times higher than traditional systems, API 9D LiDAR can achieve micron-grade precise measurement, avoiding the issues including traditional LiDAR's sensitivity to materials reflectivity, circumscribed angle of incidence and environmental noise. From what has been discussed above, we may conclude that in the process of automobile production, LiDAR can detect the production quality of automobiles [7].

3.2. Vehicle Model Recognition System in Expressway

Different kinds of vehicles are charged at different standards on the highway. When a vehicle drives into the toll station, the LiDAR recognizes the vehicles. In the vehicle recognition system, LiDAR sends laser beams to target vehicles. The reflected laser beam coming into contact is captured by the acquirers. Recognition systems will figure out the distance between the acquirer and target vehicle through measuring laser transmit time difference. Meanwhile, LiDAR changed the emission direction according to a certain angle by inner devices, completing the all-round scan. The different distance information of vehicles can be recorded, forming the three-dimensional point cloud data, which draws the rough shape, and then through the advanced algorithm to process and analyze the collected data, it can accurately identify different models, including cars, trucks, buses and so on [8].

3.3. Intelligent Driving Assistance

Nio ES6 is an intelligent electric versatile sport utility vehicle(SUV), equipped with five car doors, five seats and numerous sensors and monitors that comprise NIO Pilot auto assistance driving system. This system functions such as lane keeping assist, automatic parking, full-speed adaptive cruise control, and more. During driving, LiDAR detects the road conditions ahead. When obstacles are detected, laser beam are reflected and caught by the LiDAR, resulting in the formation of point cloud data. This extensive point cloud can clearly display buildings vehicles, and pedestrians along the roadside. Simultaneously, signal processing unit classifies point cloud characteristics according to different types, providing reminders to the driver. The Seyond Ultra-long range and high-precision LiDAR equipped in Nio ES6 allows for far-reaching, clear, and accurate identification, assisting drivers in braking. For example, at a vehicle speed of 144 km/h, if an obstacle is 250 meters away from vehicle, it can brake in 6.25 seconds, allowing the data processing center more time for anticipation and braking [9].

4. The Impact of Lidar on the Automotive Industry

Lidar has had a profound impact on the development of automobiles in many aspects, as follows.

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Firstly, it can improve the safety of vehicles. LiDAR can obtain the precise position, distance and speed of the surrounding environment in real time, allowing the vehicle to sense potential dangers in advance and perform timely braking or avoidance maneuvers to reduce the occurrence of collisions [10]. Additionally, it can be integrated with other sensors (such as cameras, millimeter-wave radar, etc.) to provide a more comprehensive and accurate perception of the environment, improving the vehicle's safety performance in complex road conditions and adverse weather [11].

Secondly, it promotes the development of intelligent vehicles. LiDAR provides critical environmental perception data for autonomous driving and advanced driving assistance systems, and is one of the important sensors to achieve high-level autonomous driving. Through high-precision modeling and real-time monitoring of the surrounding environment, LiDAR helps vehicles realize autonomous navigation, path planning, lane keeping, automatic lane changes and other functions, thereby advancing the development of vehicles toward greater intelligence [12].

Thirdly, it optimizes vehicle design. Accurate detection of the surrounding environment helps the vehicle to sense potential dangers in advance, which is conducive to optimizing the design of active safety systems. The installation of LiDAR necessitates consideration of its positioning and coordination with other components, such as adjusting the layout of sensors and wiring harnesses and optimizing space utilization within the vehicle. In order to reduce the impact on LiDAR performance, the exterior design of the vehicle will pay more attention to aerodynamics, such as optimizing the body line, adopting a hidden design, and reducing wind resistance. The unique installation and appearance of LiDAR can introduce new elements to vehicle design, catering to the individual needs of consumers, such as unique roof styling.

Fourthly, it enhances the competitiveness of the automobile market. As consumers' demand for vehicle safety and intelligence continues to rise, cars equipped with LiDAR have certain competitive advantages. By incorporating LiDAR, vehicle manufacturers can enhance the technological appeal and added value of vehicles, attracting more consumers and thus standing out in a fiercely competitive market.

Fifthly, it promotes the ecological development of the automobile industry. The application of LiDAR has led to the growth of related industrial chains, including LiDAR manufacturers, chip suppliers, optical device manufacturers, algorithm developers. The development and expansion of these enterprises has provided more technical support and innovation impetus for the automobile industry, fostering the prosperity of the automobile industry ecosystem

5. Conclusion

LiDAR measures the distance to obstacles around the vehicle through point cloud technology, prompting the driver to pay attention to safety and ensure safe driving. This technology plays an important role in vehicle safety and driving security. The principle involves emitting laser pulses. When the pulses hit an object, they are reflected back to the receiver This information is processed by the center to generate a point cloud and perform classification, which provides the driver with road condition information, assists in driving, and thus enhances both safety and convenience. LiDAR makes electric vehicles safer and more intelligent while benefiting from energy savings and environmental protection.

However, there are still some deficiencies in this paper. For example, there is a lack of data, insufficient literature and some argumentative gaps. In addition, LiDAR can be applied to more manufacturing fields. With advancements in science and technology, LiDAR will find applications in more industries and sectors. At the same time, as more signal sensors develop, LiDAR will be integrated with and complement other sensors to provide intelligent services more effectively.

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