ASEAN Journal of Science and Engineering

Journal homepage: http://ejournal.upi.edu/index.php/AJSE/

Object Detection for Autonomous Guided Vehicle

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ABSTRACT

In recent years camera networks have been widely used in several applications such as surveillance, video conferencing, etc. The autonomous vehicle can reduce critical fatalities and injuries. Thus, an autonomous vehicle is the solution to this eliminating the possibility of human error and drastically changing the danger associated with the motor. In the rural environment, a lack of accuracy and estimation of the vehicle can be observed since the roads are not well constructed, however, in an urban area, it is very easy to detect landmarks on roads. The joint observation model is used for compensating the error of individual observations and the state of the vehicle. The purpose of this paper is to present the design of an obstacle detection system using LIDAR for an autonomous guided vehicle. LIDAR is mostly used in an autonomous vehicle to detect obstacles. It provides the exact location of obstacles in front of the vehicle. The main motto of using the LIDAR camera is to detect obstacles and send data to the controller. The Observational-Experimental methodology was used for this research. It controls the speed of the vehicle, emergency braking when an object is being detected. An autonomous vehicle system with LIDAR can be used on one-way or two-way roads and it is widely used for industrial purposes. The autonomous vehicle is useful for one-way or two-way roads. The aim of the obstacle detection system is it reduces accidents on road and reduce human power.

ARTICLE INFO

Article History:
Submitted/Received 30 Jun 2021
First revised 04 Aug 2021
Accepted 06 Oct 2021
First available online 08 Oct 2021
Publication date 01 Des 2022

Keyword:
Autonomous Guided Vehicle,
Obstacle Detection,
LIDAR.

1. INTRODUCTION

A self-driving vehicle or autonomous car is a vehicle that is equipped for detecting its condition and moving with practically no human input. Self-governing autos consolidate an assortment of sensors to see their environment, for example, RADAR, LIDAR, SONAR, GPS, and inertial estimation units. LIDAR and RADAR technology are used in an autonomous vehicle, detect near as well as far obstacles aligned with the camera sensor to capture obstacles on-road and capture the surroundings. LIDAR system utilizes a beam of light with an infrared laser diode reflecting on a rotating mirror. It is the most effective and accurate method compared to RADAR; however, LIDAR has a limited range. Most vehicles use a combination of cameras, and these two technologies, to look forward and convey collision warnings or apply automatic emergency brakes. This technology is used for applying emergency braking, pedestrian detection, and object or obstacle detection. It is widely used in an autonomous vehicle to detect obstacles. Moreover, it provides the exact location of obstacles in front of the vehicle. The system is mostly used in agriculture and airport.

Many researchers develop a self-driving vehicle (Naseri & Azmoon, 2011; Bhangale *et al*., 2016; Kewate *et al*., 2014; Ashok *et al*., 2015). Previous studies (Naseri & Azmoon, 2011; Bhangale *et al*., 2016; Ashok *et al.,* 2015) have demonstrated the use and implementation of LIDAR for sensing and detecting obstacles, however, the ways were inconvenient and most expensive. For communication between a sensor and vehicle, the three methods considered are complementing, co-operative and competitive. All models in data fusion can get signals, extract features and make a decision.

The purpose of this research is to provide an advantage of an autonomous vehicle system (self-driving car) to reduce the number of accidents on the road. There are several challenges to build an autonomous vehicle consisting of obstacle detection, lane detection, pedestrian detection, and few significant others. Safety factors such as emergency responders can respond rapidly if in any emergency.

The novelties of this research are authorities and faculties of the Rajarambapu Institute of Technology. The data mentioned in the paper is acquired as a part of the project from the students and is accurate.

2. LITERATURE REVIEW

Some researchers introduced a multi-model fusion technique in the camera network. The system is widely used in many applications like surveillance applications, Ambient Intelligence, Videoconferencing, and automotive application. The architecture of a data fusion system depended on the logical function. Multi-modal fusion technique in camera networks is provided to architectural potentialities, limitations, and requirements.

Some researchers presented Autonomous Vehicle Research Platform (AVRP) which was considered extremely useful. They used new sensors like light detection and ranging (LIDAR), RADAR, camera, and Ultrasonic sensor also use a new algorithm for an autonomous vehicle. These sensors are mounted on the car in location optimized detection range and viewing angle. AVRP could fuse sensor data obtained in the 360-degree view of the environment (Naseri & Azmoon, 2011).

Some researchers had discussed the function of RADAR implying a data fusion algorithm. Three data fusion algorithms i.e., Averaging, Bayesian, and Dempster-Shafer were simulated. The dempster-Shafer algorithm was used for the two-cell network. Probability Data Fusion (PDF), Multiple Hypothesis Model (MHM), and Interacting Multiple Model (IMM) are some of

DOI: http://dx.doi.org/10. 17509/xxxx.xxxx
p- ISSN 2776-6098 e- ISSN 2776-5938

the explained data fusion algorithms in RADAR. Data Fusion algorithm prepared in fuzzy logic, neural network, and image processing.

Some researchers have presented an intelligent autonomous vehicle technology. It used various sensors, cameras, radar, and LIDAR sensors. It has been developed and applied to monitor the vehicle and environment around it as well as requesting the vehicle or driver to take action as per the situation.

Some researchers had presented a high-level fuzzy logic guidance system for an autonomous vehicle and recovery mission of an autonomous underground vehicle. A mission controller was developed to transport, deploy and recover the autonomous underground vehicle. Two fuzzy logic controllers are developed to guide USV throughout the autonomous launch and recovery mission, a waypoint-heading fuzzy logic guidance controller and a rendezvous docking fuzzy guidance controller.

Some researchers had presented various technologies that enabled autonomous vehicles. The author introduces various sensors such as ultrasonic sensors, camera sensors, etc. Only a single sensor not provided all the required information so the fusion of sensors was used for fully autonomous vehicles. The author had presented safety factors such as emergency braking, speed control, blind-spot detection, and others.

Some researchers had proposed that an autonomous vehicle able to sense its surrounding data automatically and driving the vehicle without any human interface. An autonomous vehicle could sense the surrounding environment using a GPS, LIDAR, RADAR, Camera, etc. Raspberry pi acted as the primary processor of the vehicle. The controller had responsible for obstacle detection as well as its separation based on its properties. The biggest advantage of self-driving or autonomous cars was to reduced accidents on the road. There were several challenges to build an autonomous vehicle. The challenges included obstacle detection, lane detection, localization, etc (Bhangale *et al.,* 2016).

Some researchers presented the importance of incorporating holistic and feature-based localization systems in an autonomous vehicle. The localization system is represented by calculating the matching score between LIDAR and map images. Localization is the most important pillar for enabling autonomous vehicles.

Automatical speed of vehicle and accident-avoidance system by using eye blink sensor and the ultrasonic sensor was developed. When any obstacle is detected near the vehicle depends upon its range it controls the speed of the vehicle automatically. If the driver is sleeping more than 30 seconds, then the eye blink sensor detects it and stops the car automatically, and gives the alert alarm to drive.

Some researchers had presented an autonomous underwater vehicle technology. The vehicle works in an unknown and complicated ocean environment so it is essential to it has a safe and reliable ability to avoid obstacles underground. The obstacle avoidance system is based on a method that can reflect dynamic obstacle avoidance ability which combines local obstacle avoidance planning, motion control. The method includes task goal, obstacles, and control ability of the autonomous underwater vehicle.

Other researchers had presented the architecture of the speed control system. This system used a combination of different color detecting sensor technology systems. This system is portable and easily adaptable to control the speed of the vehicle at limiting road areas to reduce accidents. By using this system control speed of the vehicle and avoid accidents. The accident and rash driving are reduced up to 80 percent and save lives (Kewate *et al*., 2014).

Other researchers had presented that joint observation model and tried to optimize it by using Markov Chain Monte Carlo (MCMC) method. A sensor fusion algorithm was used to implement the navigation system and improved the positioning technique. Positioning

DOI: http://dx.doi.org/10.17509/xxxx.xxxx
p- ISSN 2775-6793 e- ISSN 2775-6815

technologies based on GPS receiver. It is necessary to develop a method for fuse data from different onboard sensors of the vehicle when GPS data are poor. Four laser scanners have been installed on the vehicle to avoid an obstacle, pedestrian, and for local navigation (Ashok *et al.,* 2015).

Other researchers had present that now a day's automation is used widely in industry. This paper described the application of the laser triangulation principle of LIDAR. LIDAR along with the LIDAR camera is extensively used for the measurement of the height of objects from the surface based on mathematics and geometry. This principle is implemented by using the LIDAR camera. Here required image processing for parameter extraction along with line extraction algorithm (Ashok *et al.,* 2015).

3. METHODOLOGY

This research includes the use of the observational-experimental methodology. **Figure 1** shows a flow chart of the entire process. Primarily, interfacing of RPLIDAR A1M8 and Raspberry Pi. Followed by the initialization of LIDAR. LIDAR will start rotating in 360-degree and cover 600 mm distance. It gives output readings in the form of distance and angle. If the obstacle is in the range of 600 mm, hence the obstacle will be successfully detected and data will be passed on indicating the breaks to be applied.

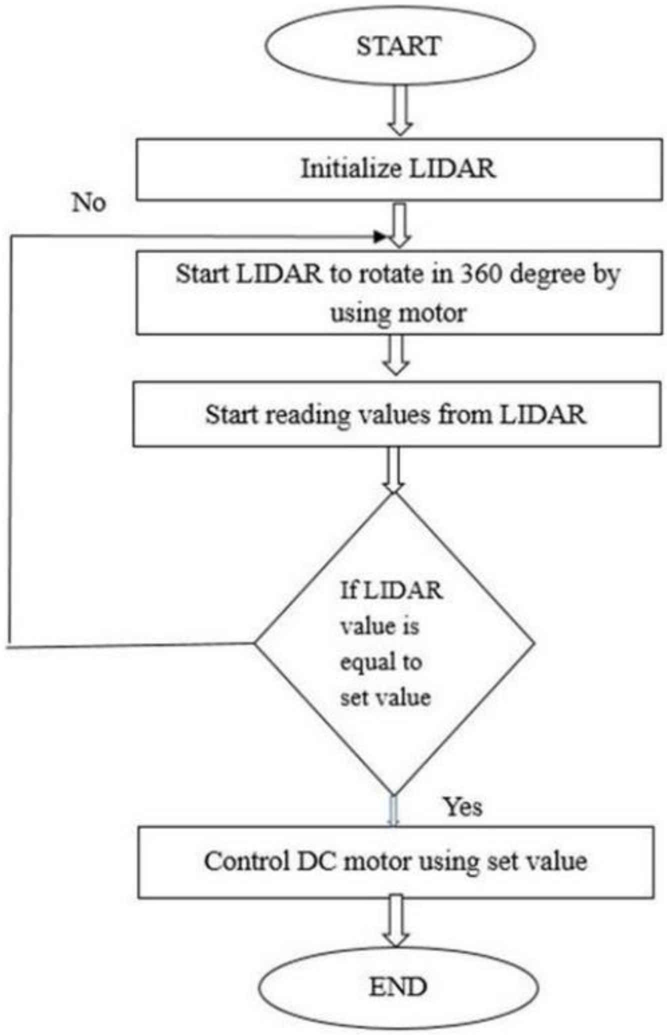


Figure 1. Flow Chart.

DOI: http://dx.doi.org/10. 17509/xxxx.xxxx
p- ISSN 2776-6098 e- ISSN 2776-5938

4. RESULTS AND DISCUSSION

4.1. Laser Triangulation Ranging Principle:

LIDAR works on the laser triangulation principle. **Figure 2** shows the working of the laser triangulation principle of LIDAR. More than 2000 times per second distance data is measured by the system along with high0-resolution distance output. Triangulation is a technique is used to find the distance of a point from a fixed known line, provided that angles to the line of point are known.

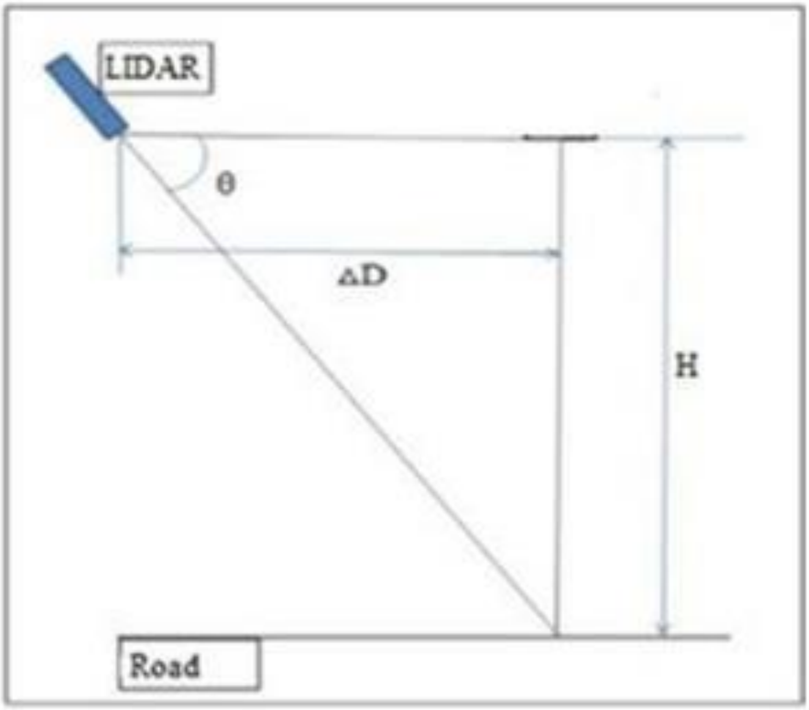


Figure 2. Laser triangulation Ranging Principle.

LIDAR is perpendicular to the road (surface). Distance between laser and LIDAR is D. Distance between LIDAR and surface is H. Following is the equation for height (H).

$$H = D * \tan(\theta)$$

This equation is used for calculating the height of an object from the road/surface.

4.2. Scanning speed of LIDAR:

LIDAR requires a fixed scanning speed wherein; the host system can control motor speed using a PWM driver. The host system can maintain the recording interval time between two adjacent measurement sample data response with start flag bit S set to 1(S=1), called T. The interval time represent 360 degrees scanning time. So actual scan speed can be calculated using the following equation.

$$RPM = [(1/T) *60].$$

The length and width of the test setup are 250 mm and 200 mm respectively. The LIDAR is mounted at the Top Front of the car. When an obstacle is within the range of LIDAR it gets detected. This signal is sent to the controller and accordingly braking and steering action take place.

DOI: http://dx.doi.org/10.17509/xxxx.xxxx
p- ISSN 2775-6793 e- ISSN 2775-6815

4.3. Results observed on Python IDE:

Figure 3 shows there are black marks at a specific distance from the center which indicates there are obstacles within the LIDAR range and the distance.

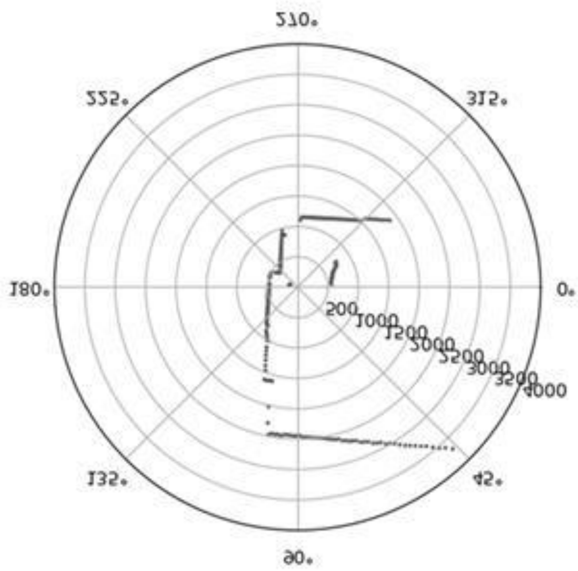
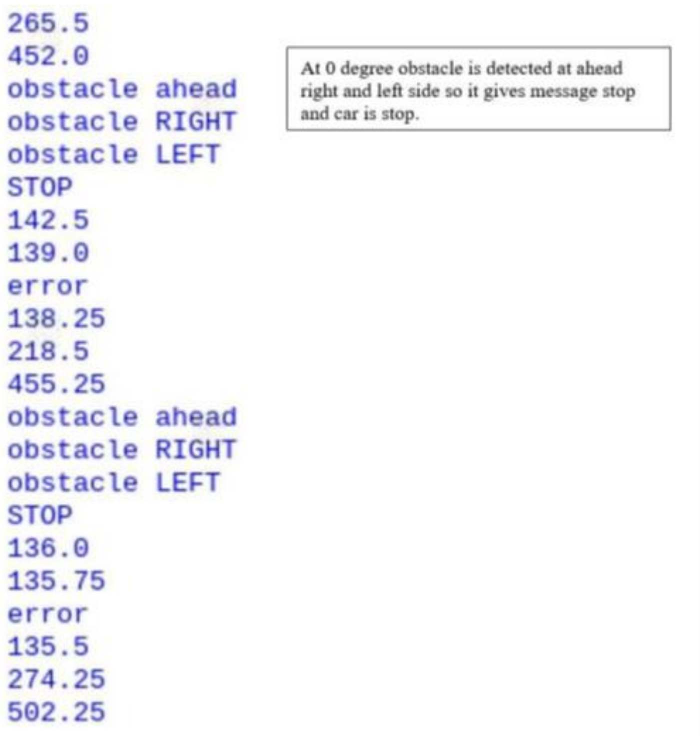


Figure 3. Scanning obstacles by using LIDAR.

4.4. Result observed when obstacle detected at all sides of car:

Figure 4 shows that when the obstacle is detected at the Front, Right and Left sides of LIDAR or car then the controller gives the order to stop the vehicle and when one of the obstacles is removed or found a free root or side then the vehicle is turned to that side.



```
265.5
452.0
obstacle ahead
obstacle RIGHT
obstacle LEFT
STOP
142.5
139.0
error
138.25
218.5
455.25
obstacle ahead
obstacle RIGHT
obstacle LEFT
STOP
136.0
135.75
error
135.5
274.25
502.25
```

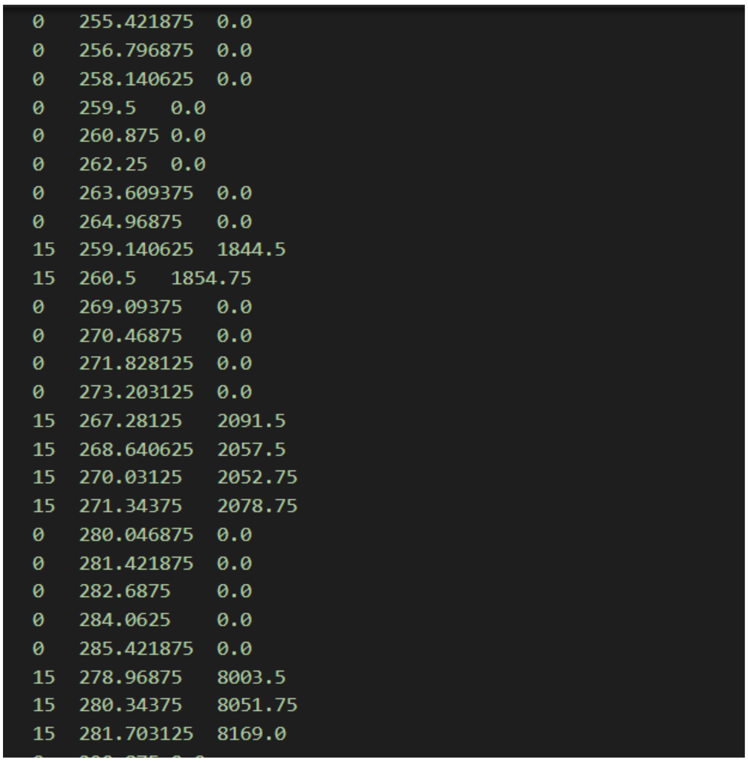
At 0 degree obstacle is detected at ahead right and left side so it gives message stop and car is stop.

Figure 4. Obstacle at the front, right, and left of the vehicle.

DOI: http://dx.doi.org/10. 17509/xxxx.xxxx
p- ISSN 2776-6098 e- ISSN 2776-5938

4.5. Measurements of LIDAR

The output cannot be viewed constantly as LIDAR continuously rotates and takes multiple inputs at one time as demonstrated by **Figure 5**. The following outputs are recorded for better understanding.



```
0   255.421875  0.0
0   256.796875  0.0
0   258.140625  0.0
0   259.5   0.0
0   260.875 0.0
0   262.25  0.0
0   263.609375  0.0
0   264.96875   0.0
15  259.140625  1844.5
15  260.5   1854.75
0   269.09375   0.0
0   270.46875   0.0
0   271.828125  0.0
0   273.203125  0.0
15  267.28125   2091.5
15  268.640625  2057.5
15  270.03125   2052.75
15  271.34375   2078.75
0   280.046875  0.0
0   281.421875  0.0
0   282.6875    0.0
0   284.0625    0.0
0   285.421875  0.0
15  278.96875   8003.5
15  280.34375   8051.75
15  281.703125  8169.0
```

Figure 5. Measurements of LIDAR.

5. CONCLUSION

The purpose of this paper is to present the design of an obstacle detection system using LIDAR for an autonomous guided vehicle. LIDAR is mostly used in an autonomous vehicle to detect obstacles. It provides the exact location of obstacles in front of the vehicle. The main motto of using the LIDAR camera is to detect obstacles and send data to the controller. The Observational-Experimental methodology was used for this research. It controls the speed of the vehicle, emergency braking when an object is being detected. An autonomous vehicle system with LIDAR can be used on one-way or two-way roads and it is widely used for industrial purposes. The autonomous vehicle is useful for one-way or two-way roads. The aim of the obstacle detection system is it reduces accidents on road and reduce human power.

6. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. Authors confirmed that the paper was free of plagiarism.

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DOI: http://dx.doi.org/10. 17509/xxxx.xxxx
p- ISSN 2776-6098 e- ISSN 2776-5938