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Obstacle Detection using LIDAR

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Abstract- **For Autonomous Vehicle, Obstacle Detection is one of the primary tasks. A number of sensor systems are available for obstacle detection. One kind of such sensor system is LIDAR (Light Detection and Ranging) system known for its high accuracy in measuring distances. LIDAR is commonly used to make high-resolution 2D/3D map of the environment. This project uses RPLIDAR A1 Sensor is mounted on the top of the vehicle. RPLIDAR A1 Sensor is 360 degree 2D Laser Scanner (LIDAR) Sensor detects the obstacles within 6 meter range. Point cloud output from the RPLIDAR sensor provides the necessary data for robot software to determine where obstacles exist in the environment and where the robot is located related to those obstacles. Hector_slam contains ROS (Robot Operating System) packages related to performing real-time SLAM (Simultaneous Localization and Mapping). In other words using information from RPLIDAR A1, hector_slam built a map of environment and show detected obstacles and where vehicle is located related to the map. Also, this vehicle uses two Laser Sensors for its movements. Laser sensors are attached in front of the vehicle. One is on Left side and another is on Right side of the vehicle. Laser Sensors detect obstacles and they avoid collision with the obstacles.**

Keywords**:- RPLIDAR, Laser Sensor, ROS, SLAM, Raspberry Pi, Arduino.**

I.INTRODUCTION

Advanced Driver Assistance Systems (ADAS) are the technologies having rapidly getting smarter and safer? Similarly, there is a race to develop truly self-driving vehicles which accelerates at a rapid space. Wind the clock back a decade or so and all vehicles on the road were entirely dependent on the eyes, ears and attention span of their human drivers. Despite some niche and luxury examples, mainstream vehicles had no systems to warn drivers of potential hazards and no way to help them to avoid an accident. Self-driving vehicles are generally safer than vehicles driven by humans.

In stressful situations when a person would panic and react intuitively, an autonomous vehicle can react rationally. It can see possible paths, calculate outcomes and then select the best one based on all that analysis. An autonomous vehicle has number of benefits to society, including prevention of road accidents due to human error. Autonomous Vehicle reduces spending on fuel, parking, insurance, healthcare and fines [1].

Obstacle detection is primary requirement of Autonomous Vehicle. For obstacle detection, there are a number of sensors systems are available in the market. Most commonly used sensor systems include LIDAR (Light Detection and Ranging) system, Vision System, ultrasonic, RADAR (Radio Detection and Ranging) system. This project used LIDAR system for obstacle detection. There are 3 categories of LIDAR systems: 1D, 2D and 3D. But, 3D LIDAR systems are expensive so, this project used 2D LIDAR system. This project used inexpensive RPLIDAR A1M8 sensor is a two-dimensional laser scanner (LIDAR) sensor is made by SLAMTEC. The 360 degree 2D Laser Scanner (LIDAR) Sensor detects the obstacle within 6 meter range [2]. Also, this project uses two Laser Sensors. Laser sensor emits laser light and laser light is then reflected by the object to be detected. Laser Sensors detect obstacles and they avoid collision with the obstacles [3].

II. LITERATURE SURVEY

The authors explained the important information of Sensors used for Obstacle Detection in the research paper [4]. Obstacle detection is a widely studied field in the automotive industry. A number of sensor systems used for obstacle detection. Sensor Systems are classified into two types Active Sensor and Passive Sensor. Passive sensors can only be used to detect energy when the naturally occurring energy is available. Active sensors provide their own energy source for illumination and that energy is reflected by target objects.

Most commonly used sensor systems are LIDAR (Light Detection and Ranging) sensor system, RADAR (Radio Detection and Ranging) sensor system, SONAR (Sound Navigation and Ranging), Vision systems. In report [5], the authors have presented Development of a Ground Robot for Indoor SLAM using Low- Cost LiDAR and Remote LabVIEW HMI. Simultaneous Localization and Mapping (SLAM) is one of the key topics in the field of Robotics. SLAM is useful for creating and updating maps of an unknown environment show detected obstacles and robot location related to the map. This report described one of SLAM techniques. HectorSLAM relies on scan matching algorithms. The Gaussian-Newton method is used to solve the scan matching problem, which finds the rigid transformation that best fits the laser beams with the map.

The HectorSLAM package, available in ROS was used with a Raspberry Pi to implement SLAM and build maps. Two options for viewing maps on Remote Machine. First is Running ROS across multiple machines and second is Map sending via TCP.

The Robot Operating System (ROS) framework is widely used in Robotics or autonomous projects. It provides tools and libraries for obtaining, building, writing and running code across multiple computers. Using information from LIDAR, ROS packages provides laser-based SLAM (Simultaneous Localization and Mapping). From basic concept to practical programming and robot application all are covered in book [6].

In research paper [7], the certain authors have presented Characteristics of different sensors used for Distance Measurement. In this paper, Laser Sensor, Ultrasonic Sensor and IR Sensor features are described. These three sensors are used for obstacle detection and obstacle avoidance. Laser Sensor emits laser light and whenever obstacle comes ahead of it, these light is reflected from the obstacle and reflected light detected by detector.

In research paper [8], the authors have also presented the implementation of DC Motor Controlling Techniques. Different types of motors AC, DC, Servo or stepper are used depending upon the application. Out of these DC motors are widely used because of easier controlling.

In this paper, Arduino mega board, L298N motor driver and GM37-520 gear-box dc motor are used as hardware devices. This paper provides working principle and implementation of software and hardware and their applications.

III. WORKING PRINCIPLE OF LIDAR

LIDAR stands for Light Detection and Ranging. LIDAR devices measure distances by emitting laser light on the object and interpreting the results from the reflected light (LIDAR uses the ultraviolet, visible or near-infrared source to sense objects).

These distance measurements can be used for all sorts of applications such as scanning objects, measuring speed, size, position, movement, create map, providing data on a vehicle's surroundings for autonomous navigation and much more. But how does this fantastic technology work?

Mostly LIDARs are based on two principles. One is Laser Triangulation Ranging and another is TOF principle. In Laser Triangulation ranging method, a Laser transmitter emits laser light onto the object.

The reflected light falls incident onto a receiving element at a certain angle depending on the distance. They are so named because the sensor enclosure, the emitted laser light and the reflected laser light form a triangle.

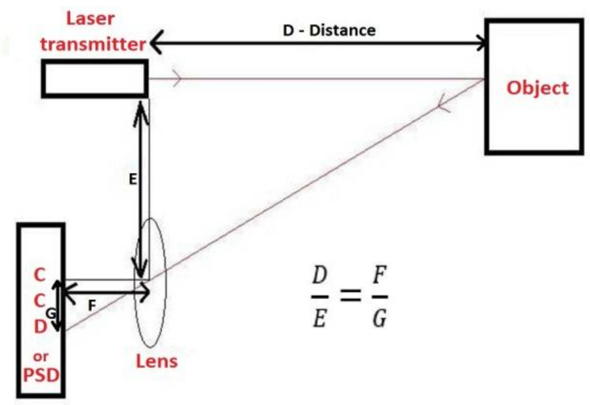

Fig 1. Laser Triangulation Ranging method.

D is calculated by

$$D = \frac{F \times E}{G}$$

As the distances E and F are known, by measuring the G value (in this case, by the CCD or PSD), then calculates the Distance D [9]. TIME OF FLIGHT method calculates distance based on the flight time of the measured light.

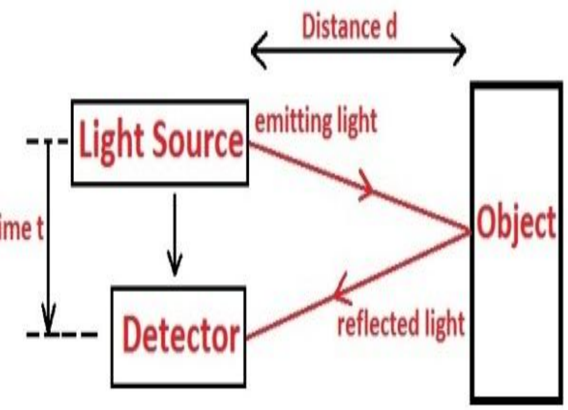

Fig 2. Time of Flight Method.

The distance (d) is determined by multiplying the speed of light (c) by the time (t) required to travel the distance from emitter to detector:

$$d = \frac{c * t}{2}$$

The measured time represents the traveling the distance between the system and object twice (from emitting to the object and return to the receiver from the object) and therefore must be reduced by half to result in the actual range of the target [10][11].

IV. DESIGN AND IMPLEMENTATION

1. Flowchart:

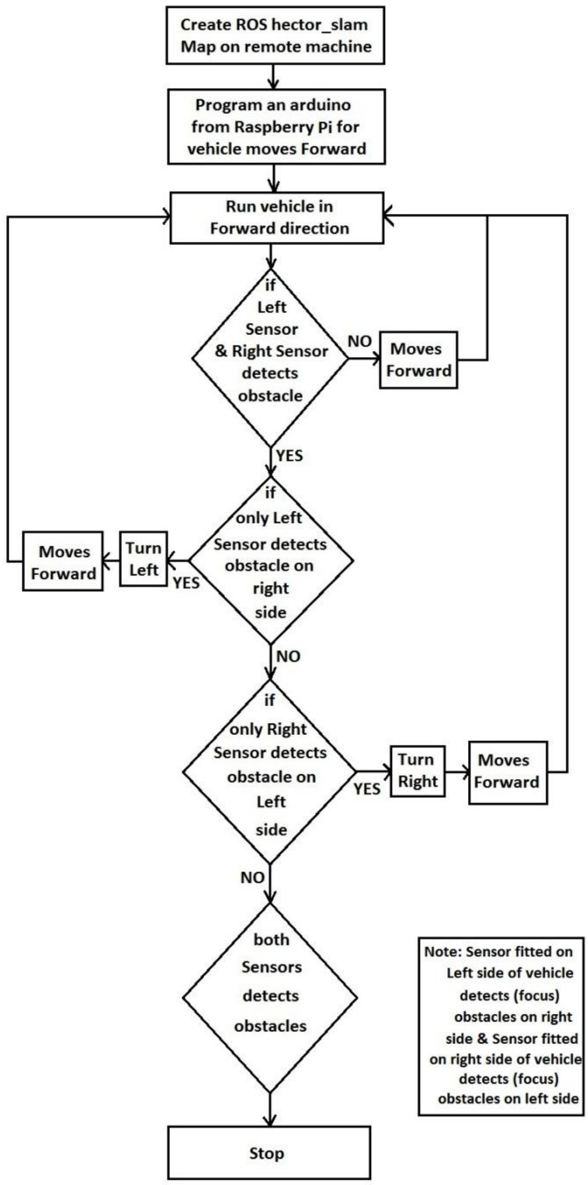

Fig 3. Flowchart.

- **Step 1:** Set up VNC Viewer on Laptop to view Raspberry Pi OS desktop environment and controlling Raspberry Pi remotely (Downloaded official image file "RASPBIAN STRETCH WITH DESKTOP" from Raspberry Pi's official website https://www.raspberrypi.org).
- **Step 2:** Increasing swap space size of Pi for faster compiling (100MB to 1024MB) [12].
- **Step 3:** Installing ROS Kinetic on Raspberry Pi [13].
- **Step 4:** Installing Arduino ide Software on Raspberry Pi (from https://www.arduino.cc/).
- **Step 5:** Installing ROS Kinetic on Ubuntu 16.04 in LAPTOP (already installed Ubuntu 16.04 on VirtualBox) [14].
- **Step 6:** Installing Raspicam_node package on Linux LAPTOP and Raspberry Pi [15].
- **Step 7:** Installing Rplidar_ros packages on Linux Laptop & Raspberry Pi. Installing Rplidar hector_sl am ROS package on Linux Laptop [16].
- **Step 8:** ROS on Multiple Machines. Connecting Raspberry Pi to Linux Laptop via WiFi (Setting for Viewing Maps on Remote Machine) [17]. After that creating hector_slam map on Linux Laptop (remote machine).
- **Step 9:** In Software part, RVIZ is a 2D/3D visualizer for ROS framework. Generated 2D point cloud data from RPLIDAR, used in mapping, localization and object/environment modeling.

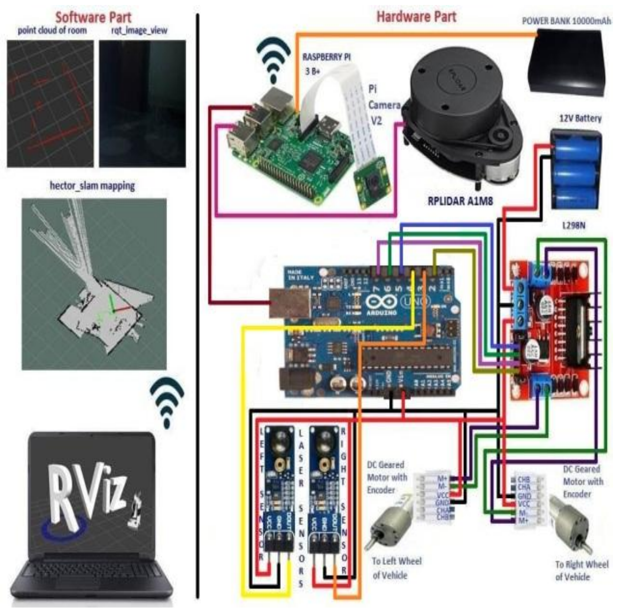

Fig 4. The project is divided into two parts. One is Software and another is Hardware.

Information obtained from RPLIDAR A1 Sensor, hector_slam ROS package performing real time SLAM (Simultaneous Localization and Mapping). hector_slam package built a map of environment. This map showed detected obstacles and exact position of the vehicle related to the map**.** In Hardware part, RPLIDAR A1 Sensor is mounted on the top of the vehicle. RPLIDAR A1 is connected to USB port of Raspberry Pi. Two DC Geared Motor with Encoder

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are connected to Arduino via motor driver module. Two Laser Sensors are used for vehicle movements. Laser Sensors are connected to the arduino.

- **Step 10:** Programming an arduino from Raspberry Pi for vehicle moves forward.

V. RESULTS

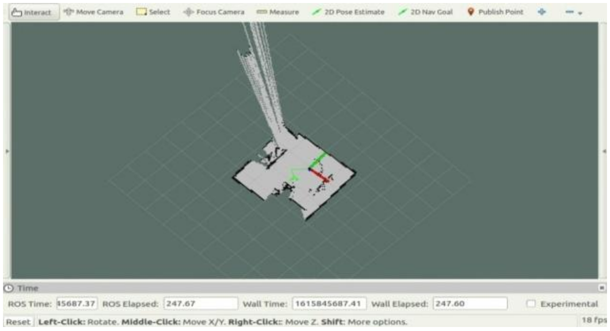

Fig 5. Screenshot of hector slam map.

Fig 6. Map shows obstacles and where vehicle is located related to map.

The hector_slam package provides laser-based SLAM (Simultaneous Localization and Mapping). In above map (Fig. 6), Lighter Colours are Free space indicates that there are no obstacles at this position and the vehicle can move freely. Dark colours are obstacles indicate the vehicle can't pass through while moving; otherwise, it will collide with obstacles.

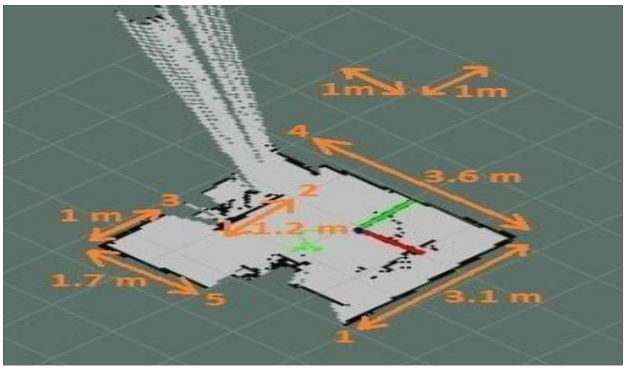

Fig 7. Map of a room with measurements.

Table 1. Comparison between map and real-life measurements.

Length	Real Measurement (m)	Approximate hector_slam map measurement (m)
1	3.1	3.1
2	1.2	1.2
3	1	1
4	3.6	3.6
5	1.7	1.7

The scale of the maps produced by HectorSLAM are accurate, the five lengths depicted in orange in Fig. 7 were compared to real- life measurements. Each square on the map represents 1 meter square. Real measurements and hectorslam map measurements are matched.

Fig 8. Screenshot of live streaming on Laptop using rosrun rqt_image_view.

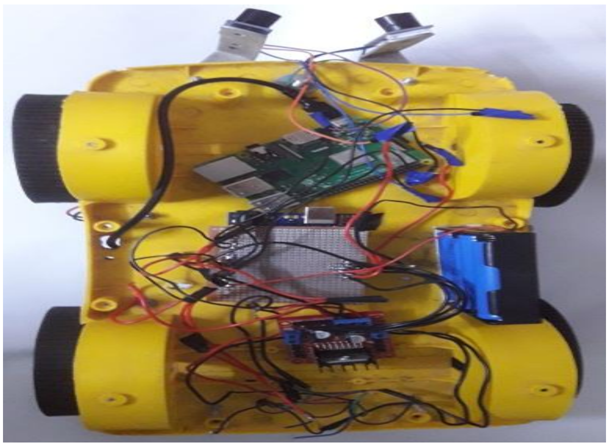

Fig 9. Connections of components, devices, sensors (used PCB for avoiding loose connections).

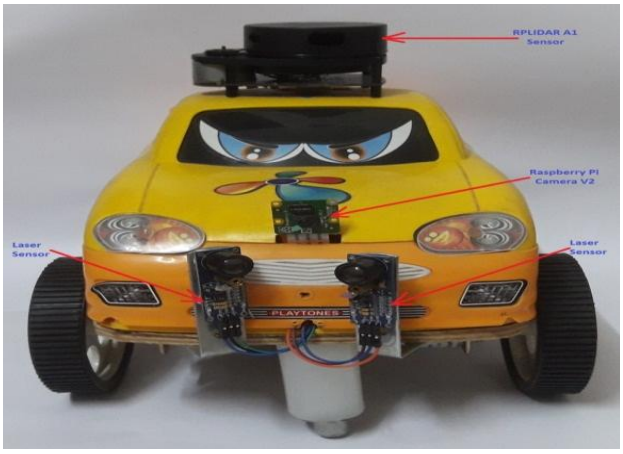

Fig 10. My Vehicle (RPLIDAR A1 sensor is mounted on the top of the vehicle. Two Laser Sensors and Raspicam V2 camera are attached on front of vehicle.)

This vehicle uses two Laser Sensors for its movements. Laser sensors are attached in front of the vehicle. One is on Left side (for functioning on right side) and another one is on Right side (for functioning on the left side) of the vehicle. Whenever the vehicle is going on the desired path the Laser sensor emits laser light.

Whenever an obstacle comes ahead of it laser light reflected back from an object (when it detects an obstacle within range it will send an output LOW and for no obstacle it will send an output HIGH) and that information is passed to the arduino. Arduino controls the motors left, right, forward based on sensor signals. If no obstacle detected by the sensors then vehicle moves forward. If obstacle detected by left sensor at right side then vehicle turns left and avoid obstacle.

If obstacle detected by right sensor at left side then vehicle turns right and avoid obstacle. If both sensors detects obstacles then vehicle stop as per priority (you can change priority to moves backward then turn left/right). Also you can stop vehicle by changing Arduino program from Raspberry Pi.

VI. ADVANTAGE

LIDAR data has a higher accuracy of measurement because of its short wavelength. LIDAR is commonly used to make high-resolution 2D/3D map of the environment. The beam of a LIDAR is often quite narrow.

There are Lidars that measure at several hundred azimuth angles and elevation angles in one sweep. Thus LIDAR create a map which could potentially give much more detailed information of objects and their surrounding environment. Lidars are relatively insensitive to any light conditions.

VII. APPLICATIONS AND FUTURE SCOPE

With the help of LIDAR, autonomous vehicles travel smoothly and avoid collisions by detecting the obstacles ahead. The LIDAR creates a map of environment which gives information, such as how far and at what degree the obstacle is located.

This information will be used by the path planning algorithm to modify its path so as to avoid the obstacle and reroute the vehicle's path. This improves the safety of the people and makes autonomous cars less prone to accidents because the risk of human negligence and rash driving is absent. Hence, No Doubt the Autonomous Vehicle has a bright future.

VIII. CONCLUSION

The above RPLIDAR A1M8 Sensor and Laser Sensors were studied. Information obtained from RPLIDAR, hector_slam successfully built a map of environment and showed detected obstacles and vehicle position related to map. Whenever Vehicle moves forward and obstacle comes ahead of it then Laser Sensors easily detect obstacles and avoid collision with the obstacle.

REFERENCES

[1] Simone Pettigrew, Driverless cars really do have health and safety benefits, if only people knew, July 5, 2018.

[2] https://theconversation.com/driverless-cars-really-do-have-health-and-safety-benefits-if-only-people-knew-99370

[3] Slamtech RP LiDAR A1 Introduction and Datasheet, slamtec.com

[4] Laser Sensor User Manual, https://www.waveshare.com/w/upload/archive/9/93/20150824040949%21Laser-Sensor-UserManual.pdf

[5] Anca Discant, Alexandrina Rogozan, Corneliu Rusul and Abdelaziz Bensrhair, "Sensors for Obstacle Detection A Survey", 2007 30th International Spring Seminar on Electronics Technology (ISSE).

[6] Jack Schubert, "Development of a Ground Robot for Indoor SLAM Using Low-Cost LiDAR and Remote LabVIEW HMI", 2018.

[7] YoonSeok Pyo, HanCheol Cho, RyuWoon Jung, TaeHoon Lim, "ROS Robot Programming Book".

[8] Pavithra B. G, Siva Subba Rao Patange, Sharmila A, Raja S, Sushma S J, "Characteristics of different sensors used for Distance Measurement", International Research Journal of Engineering and Technology (IRJET), Volume: 04 Issue: 12, Dec-2017.

[9] Myat Mon Thein, Kyaw Soe Lwin, "Implementation of DC Motor Controlling Techniques", International

Journal of Science, Engineering and Technology Research (IJSETR), Volume 8, Issue 7, July 2019.
[10] João António Santos Dias Fonseca, Military Academy / IST, Distance measurement systems using lasers and their applications.
[11] Jingyun Liu, Qiao Sun, Zhe Fan, Yudong Jia, TOF Lidar Development in Autonomous Vehicle, 2018 the 3rd Optoelectronics Global Conference.
[12] N.F. Jansen, "Short Range Object Detection and Avoidance", Traineeship Report November 17, 2010.
[13] How to change Raspberry Pi's Swapfile Size on Raspbian, https://www.bitpi.co/2015/02/11/how-to-change-raspberry-pis-swapfile-size-on-rasbian/
[14] Installing ROS Kinetic on the Raspberry Pi, http://wiki.ros.org/ROSberryPi/Installing%20ROS%20Kinetic%20on%20the%20Raspberry%20Pi
[15] Ubuntu install of ROS Kinetic, http://wiki.ros.org/kinetic/Installation/Ubuntu
[16] Installation of raspicam_node package, https://github.com/UbiquityRobotics/raspicam_node
[17] RPLIDAR Tutorial Review, https://www.dfrobot.com/blog-1464.html.