IOP Conf. Series: Materials Science and Engineering **384** (2018) 012058 doi:10.1088/1757-899X/384/1/012058

Robot Operating System (ROS) Compatible Low Cost Rotating Light Detection and Ranging (Lidar) Design

N S Widodo[1], S A Akbar[1] and A Rahman[2]

[1]Program Studi Teknik Elektro, Universitas Ahmad Dahlan, Jl Prof Dr Soepomo SH, Yogyakarta
[2]Program Studi Sistem Informasi, Universitas Ahmad Dahlan, Jl Prof Dr Soepomo SH, Yogyakarta

*nuryono.sw@ee.uad.ac.id

Abstract. Robot Operating system (ROS) is collection of software frameworks for robot software development. Researchers that work with ROS will have an opportunity to use or to be exact to reuse any software framework from another researcher as long as they use a similar robot platform, or similar device that has been include in the ROS. This paper present a design for a low cost rotating Lidar that compatible with ROS. As all we know distance measurement is the basic for building an autonomous capability for robots. Rotating lidar is among one the most popular device used to acquire this kind of information. However most of them are not suitable for low budget project because of their high cost. The design presented here tries to build a low cost rotating lidar based on Lidar Lite device with the compatibility with the ROS. The design incorporate a control board based on a microcontroller.

1. Introduction

LIDAR (Light Detection and Ranging) is an optical remote sensing technology that measure the diffused property of the light to calculate the distance or another quantity from a remote targeted object. In general it can be said that lidar is a method to measure the distance to an object or surface using laser pulse. Just like a radar, that uses a radio wave rather than light, a lidar measure the distance to an object by measuring the time elapsed between light pulse transmission and the reflected pulse detection. LIDAR technologies has been widely applied in the field of geodetic, archeology, geographic, and atmospheric surveys. Another area that benefited by the lidar technology is the area of robotic, with its main function as distance measurement sensor, the lidar has become increasingly popular in robotic, especially in the area of mobile robotic, as presented in [1]. As we all know distance information is the basic information to build autonomous robot behavior, ranging from obstacle avoidance behavior to simultaneous location and mapping, based on distance measurement information. Many researchers use vision sensor to build their robot localization ability, such as [2]-[6]. Others use ranging sensor, such as lidar to build the capability. The most popular lidar used in robotics is the scanning lidar or often mentioned as scanning laser, in which the unit is rotating continuously and performs series of distance measurement simultaneously. However the current scanning laser available on the market are relatively high cost for a small budget robotic. Fortunately, there has been a cheap lidar with the price below $200, but it lack the scanning capability compared to the higher priced lidar. This paper presented a design to build a scanning lidar based on the aforementioned cheap lidar with the compatibility to Robot Operating System (ROS).

Robot operating system or ROS, is actually not an operating system, but it rather serves as a middleware between a computer and robot related hardware or subsystem. ROS enables a robot researcher to use and reuse a package, a collection of program, including a driver for a specific robot hardware, in another robot. It provide a package for many robot platforms, sensors, or actuators commonly used both in industrial robot or research robot. Anyone also possible to build his own robot platform in ROS based on the available sensor, actuator and control algorithm packages in ROS. ROS has been used in many kind of robots, as can be found in [7]-[10]. The design presented on this paper based on a lidar sensor and rotating mechanism controlled by a microcontroller to build a rotating lidar compatible with ROS with a target cost below $400.

2. Research Methodology

The design comprised hardware configuration and software configuration. It is important to note that the design has a targeted budget not more than $400, since it's the lowest scanning lidar available in the market right now.

2.1. Hardware Configuration

The main hardware component is obviously a lidar, a Lidar Lite V3 from Garmin, as shown in figure 1, was used in this design. It has a maximum range of 40 meters, 1 cm resolution, 2.5 cm accuracy for range below 5 m and 10 cm in range more than 5m. The unit has an update rate of 270 Hz in typical, and 650 Hz in fast mode, it means that the unit is able to provide 270 measurement in 1 second in typical an 650 measurements in in 1 second in fast mode. The price tag for the unit is around $150.

Figure 1. Lidar Lite V3.

As for the rotating actuator, a stepper motor is used, stepper motor was chosen because its simplicity to obtain a consistent step of rotation, as long as it's not loaded with heavier load that its torque. The Arduino Nano is used for controlling the lidar operation and stepper rotation. It also works as message generator for the ROS through a serial connection with the computer running ROS. To eliminate a mechanical design complexity, in this case, mechanical design needed to avoid cable tangling especially the cable for the LIDAR due to its scanning/rotating movement, a Bluetooth based connection is used between the Arduino and the Computer. The overall block diagram presented in figure 2.

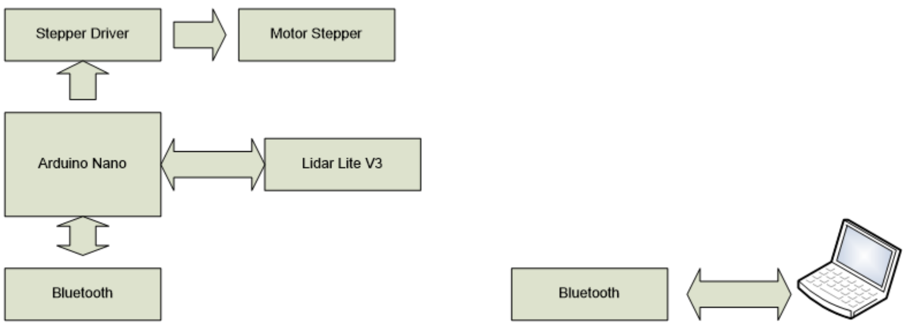

Figure 2. Block Diagram.

2.2. Software Configuration

The software section of the design serves mainly to control the operation of the lidar and the stepper motor, and to form a message containing the information from the lidar that compatible with the ROS laser scan message type. The flowchart of the software section is shown in figure 3.

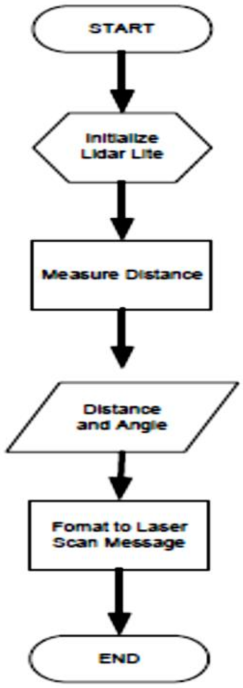

Figure 3. Flowchart.

The Lidar Lite V3 has two interfaces, I2C and PWM. The design presented here uses the I2C interface, and based on the sample code provided in from Garmin as the manufacturer of the unit, https://github.com/garmin/LIDARLite_v3_Arduino_Library [11]. After the measurement the distance information is packed together with the position of the stepper, in the form of angle, that range between 0° to 360°, as a representation of a full rotation.

For laser scanners, ROS provides a special Message type in the sensor_msgs package called LaserScan to hold information about a given scan. LaserScan Messages make it easy for code to work with virtually any laser as long as the data coming back from the scanner can be formatted to fit into the message. Base on this, the next stage conducted in the Arduino Nano is to ensure that the message its generate is has the same format with the LaserScan message in ROS so it can be processed further in ROS.

On the ROS side we need at least two functions, the first is a driver that enable the ROS to recognize and find the designed rotating lidar module and to receive a message from it, and the second is a publisher that enable another part of the ROS listen to the message and process it accordingly.

3. Result and Discussion

The rotating lidar built in this paper has been tested with ROS, especially ROS Indigo, in an Ubuntu 14.4 LTS Laptop. For verification purpose the result of the scan from the rotating lidar built was visualized using rviz. Rviz (ROS visualization) is a 3D visualizer for displaying sensor data and state information from ROS. Using rviz, user can display live representations of sensor values coming over ROS Topics including camera data, infrared distance measurements, sonar data, and more. It even has the ability to display a robot configuration on a virtual model of the robot. The scan result is displayed in rviz as shown in figure 4.

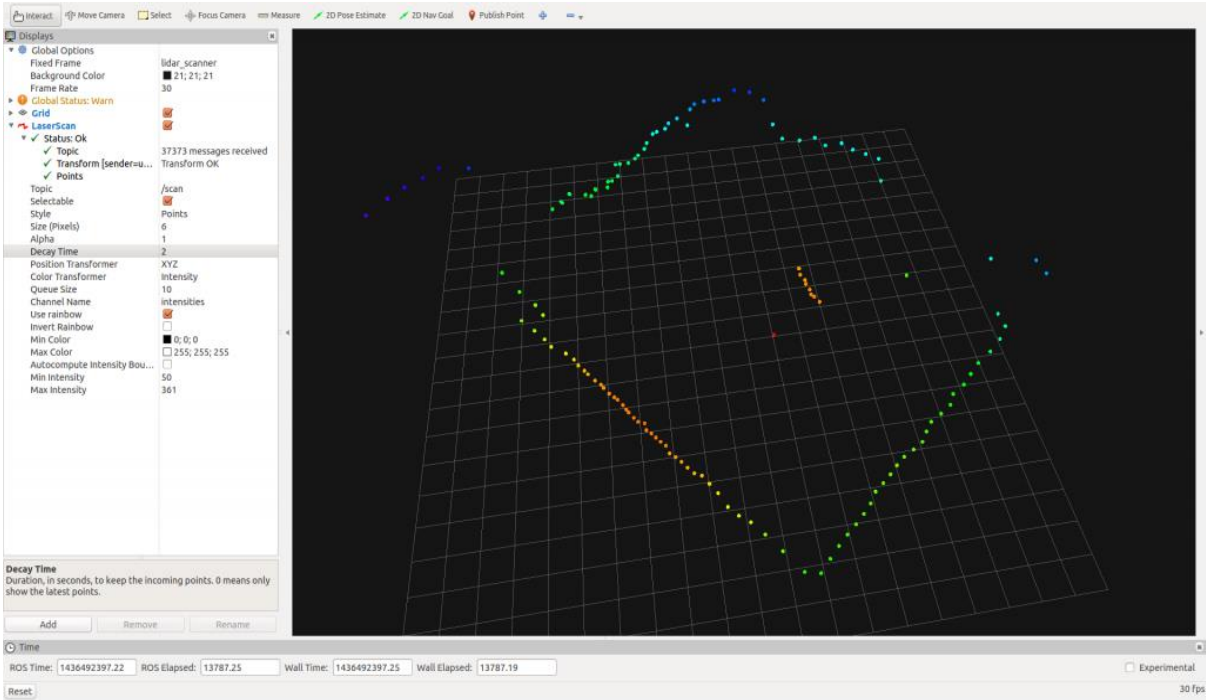

Figure 4. Scan Result in rviz.

The overall cost spent to build the rotating lidar is $195, with the detail presented in table 1.

Table 1. Cost Spent.

Component	Unit price ($)	Quantity needed	Subtotal Cost
Lidar-Lite V3	150	1	150
Stepper Motor	10	1	10
Stepper Driver	3	1	3
Arduino Nano	10	1	10
Bluetooth set	10	1	10
Li ion Battery	2	2	4
3D Printed Housing	8	1	8

4. Conclusions

Presented in this paper a design for a ROS compatible rotating lidar or laser scanner, based on the easy off the shelf part, with the overall cost under $195. As for the improvement, an encoder could be added to ensure that there is no glitch in the rotation that lead to a valid consistent scan result. Another improvement possible is to add an IMU, so with an appropriate software enhancement the unit can be used as a basic sensor to perform simultaneous location and mapping (SLAM).

Acknowledgement

This paper is a result of research conducted using *Penelitian Dosen Pemula* grant, contract number PDP-039/SP3/LPP-UAD/IV/2017.

References

[1] Oßwald S, Görög A, Hornung A and Bennewitz M 2011 Autonomous climbing of spiral staircases with humanoids *Intelligent Robots and Systems (IROS), 2011 IEEE/RSJ International Conference* 4844-4849

[2] Hoermann S and Borges P V K 2014 Vehicle localization and classification using off-board vision and 3-D models *IEEE Transactions on Robotics* **30** (2) 432-447
[3] Minaeian S, Liu J and Son Y J 2016 Vision-based target detection and localization via a team of cooperative UAV and UGVs *IEEE Transactions on systems, man, and cybernetics: systems* **46** (7) 1005-1016
[4] Lategahn H and Stiller C 2014 Vision-only localization *IEEE Transactions on Intelligent Transportation Systems* **15** (3) 1246-1257
[5] Widodo N S and Rahman A 2012 Vision based self localization for humanoid robot soccer *TELKOMNIKA (Telecommunication Computing Electronics and Control)* **10** (4) 637-644
[6] Utomo O K, Santoso D and Nugroho S 2016 Location and Position Determination Algorithm for Humanoid Soccer Robot *TELKOMNIKA (Telecommunication Computing Electronics and Control)* **14** (1) 4-13
[7] Schwarz M, Pastrana J, Allgeuer P, Schreiber M, Schueller S, Missura M and Behnke S 2013 Humanoid teensize open platform nimbro-op *Robot Soccer World Cup* 568-575 Springer, Berlin, Heidelberg
[8] Hellmund A M, Wirges S, Taş Ö Ş, Bandera C and Salscheider N O 2016 Robot operating system: A modular software framework for automated driving *Intelligent Transportation Systems (ITSC), 2016 IEEE 19th International Conference* 1564-1570 IEEE
[9] Wong K W and Kress-Gazit H 2017 From High-Level Task Specification to Robot Operating System (ROS) Implementation *Robotic Computing (IRC), IEEE International Conference* 188-195 IEEE
[10] Allgeuer P, Farazi H, Schreiber M and Behnke S 2015 Child-sized 3D printed igus humanoid open platform *Humanoid Robots (Humanoids), 2015 IEEE-RAS 15th International Conference* 33-40 IEEE
[11] Github 2016 *LIDAR-Lite v3 Arduino Library* (Online) available at: https://github.com/garmin/LIDARLite_v3_Arduino_Library