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RPLIDAR Integration Module for Obstacle Avoidance Robot

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ABSTRACT

This paper presents the project development of Obstacle Avoidance Robot, an Automated Guided Vehicle (AGV) in example, which use a LIDAR (Light Detecting and Ranging) as a sensor for obstacles detection. RPLIDAR as LIDAR sensor is integrated with Raspberry Pi 2 becoming a sensing module. The programming is done by using Python and Arduino sketch. There are other types of sensor which also be used as an obstacle detector such as ultrasonic sensor, limit switches and a few other sensors. Any information regarding the obstacle detected will then transmitted by the Raspberry Pi to Arduino Mega. Based on information received the Arduino Mega then commanding the AGV to move the robot with the avoiding obstacles abilities. The integration module successfully developed to control the AGV trajectory to move forward direction only. The studies on the AGV behavior in facing the obstacle while moving have been done, as a result it will varying the speeds of the wheel which make the AGV turning and avoiding the obstacle. The result may be implemented in any other of AGV with differential drive system.

Key words: RPLIDAR, AGV, obstacle avoidance, Mobile robot, Raspberry Pi, Arduino

1. INTRODUCTION

LIDAR (Light Detection and Ranging) is a surveying method that measures the distance to a target by firing that target with a pulsed laser light, and the reflected pulses will be measured with a sensor. Differences between the light returned can be measured as either the distance between LIDAR and the object or the surface of the object. In the world of sensor application, RPLIDAR is a sensor based on LIDAR. RPLIDAR is a low- cost LIDAR sensor suitable application in indoor [1]. The sensor capability up to 6m in range and provides 360 degree 5.5hz/ 10hz rotating frequency. RPLIDAR is applicable in Indoor localization using robots [2][3]and [9].

An AGV (Automated Guided Vehicle) is a portable robot that follows markers or wires in the floor or uses vision, magnets, or lasers for navigation. The purpose of AGV in the industry is to move materials around a manufacturing facility warehouse. The advantages that industry gain when implement AGV is reducing the work labor and increased accuracy and productivity in producing the product.

Nowadays, most the mobile robot or navigation robot need obstacle avoidance as a safety purpose. This paper [10] explained about the Safety and Security for School children's Vehicles using GPS and IoT Technology.

There is a robot that used in scientific exploration and emergency rescue, that will go through places that are dangerous for human or even impossible for humans to reach directly [4]. For a mobile robot to be able to go through challenging environments, the robots need to gather information of surrounding area to avoid obstacles. Even now in a factory or manufacturing, mobile robots or AGV (Automated Guided Vehicle) apply obstacle avoidance so that no human will make a contact with a robot that can hurt them. The example of AGV that can integrate with LIDAR using mecannum wheel [5] and [12].

One of the examples sensors used for obstacle avoidance is ultrasound sensor [6] and [11]. The working principle for ultrasound sensor is by measuring the return time of a sound wave after emitted by the sensor (transceiver). The distance of the obstacle can be detected when the sound is essentially stable. Given the ultrasound sensor is inexpensive and quite direct, there are some disadvantages or some lacking in measuring the object or obstacle based on the shape and texture. There is an error that needs to take into consideration when measuring obstacle in a different angle. Another disadvantage of using ultrasound sensor is that the sensor cannot use side by side that can cause a crosstalk, which the same frequency used by different sensor may not possible to distinguish which one has emitted a wave.

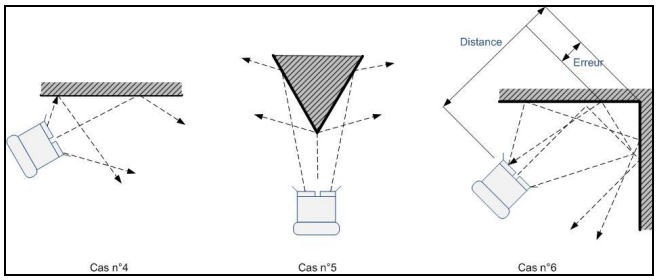

Figure 1: Ultrasound sensor object detection

LIDAR is a sensor that most suitable to use for mobile robot especially in logistics area. Inside a warehouse where there are sometimes have no light, LIDAR sensor sends its own light signal and receive it back to measure the presence of the obstacle [7]. There are also SLAM (Simultaneous Localization and Mapping) which make the mobile robot move from one point to one point in the shortest distance not to mention while avoiding obstacle. LIDAR sensor also cover 360 degree, so any kind of texture or shape is easy to detect. The application of LIDAR is in Mapping or Scanning purposes [8] and [13] and [14].

In more complex application for example vehicle, the usage of image processing or machine vision are very useful to be one of the medium in detecting the obstacle [15]. This could be very practical, except that the implementation and the study quite complicated.

2. METHODOLOGY

The purpose of this project is to create an integration module between Arduino with RPLIDAR and using the RPLIDAR as a navigation for the robot to avoid the obstacle. Raspberry Pi 2 controller will be used to be integrated with RPLIDAR. Arduino MEGA are the controllers for integrating with Raspberry Pi 2 and move the motor. Robot that will be using RPLIDAR as a sensor to avoid an obstacle is a differential drive 2 wheels robot.

Hardware development

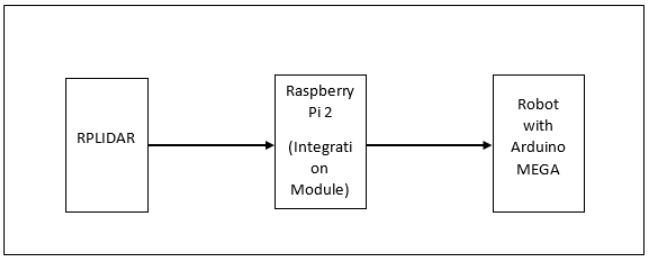

Figure 2: Block diagram of hardware development

This section will describe about the hardware development for this project. Raspberry Pi 2 is powered using 5V USB adapter. By using USB interface from Raspberry Pi 2, RPLIDAR power is supplied from Raspberry Pi 2 since power range for RPLIDAR is 3.6V-6V for the motor system and 3.6V-5V for digital system. RX and TX connection, Motor control also connected using GPIO for gather information of surrounding and send it to Pi Zero W. The connection between Raspberry Pi 2 and Arduino Mega is using a USB B type cable to receive data gather from RPLIDAR and react with moving the motor to left or right. Supply needed for operating Arduino Mega is 5V. If the power is insufficient, 5V battery will be used to support supply from Raspberry Pi 2. PWM (Pulse Width Modulation) from Arduino Mega is used for control speed of the motor to change course if there is obstacle. Figure 2 shows the block diagram relationship between RPLIDAR, Raspberry Pi, and Arduino.

RPLIDAR

RPLIDAR is a sensor based on Light Detection and Range (LIDAR). Figure 3 shows the LIDAR that being developed by ROBOPEAK. It is a 360° 2D laser scanner with the maximum detection of 6 meters. The data collected by RPLIDAR can be used in mapping, localization, and object detection. RPLIDAR can work very well indoor and outdoor environment even without sunlight as it is a laser triangulation measurement system. The scanning frequency reached up to 5.5 Hz when sampling 360 points and can be configured up to 10Hz for more accuracy.

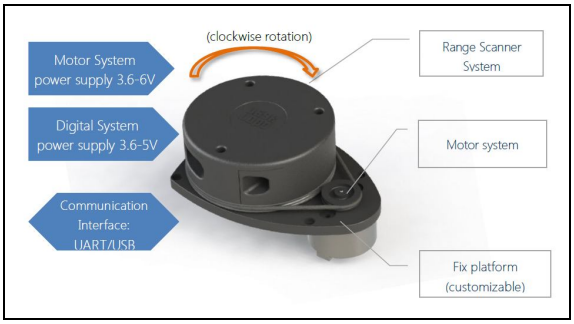

Figure 3: RPLIDAR construction

The principle for RPLIDAR to detect an =object is based on laser triangulation ranging with the usage of high-speed vision acquisition and the systems can measures data at more than 2000 times per second with high-resolution distance output. The formula for LIDAR is

$$Distance = \frac{Speed\ of\ light \times Time\ of\ flight}{2}$$

RPLIDAR emits infrared laser signal and laser signal will be reflected by the object to be detected. The signal received then being sampled in RPLIDAR and start processing the data and output distance and angle value through the communication interface.

As Raspberry Pi 2 will be the integrated module for collecting data received from RPLIDAR, the connection between the sensor and the controller is needed. By using a provided communication cable, RPLIDAR can be connected to the USB adapter. Then, by using micro-USB cable, connect the USB adapter with Raspberry Pi 2.

Software Development

This section will describe the software development for this project. The main controller to be used in this project is Raspberry Pi 2 to act as the integration module. Arduino Mega will be the controller to received data from Raspberry Pi 2 and move the motor. To be able to send the data and move the motor, there are several steps to follow. Figure 4 shows the Block diagram for software development.

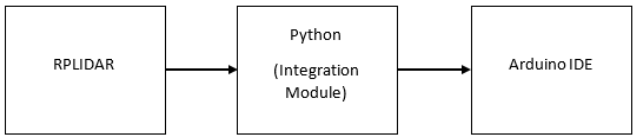

Figure 4: Block diagram of software development

Integration between RPLIDAR and Raspberry Pi 2

RPLIDAR has a built in and plug-and-play ROS (Robot Operating System). By plugging the RPLIDAR to Raspberry Pi 2 using USB cable, the motor will start rotating. Raspberry Pi 2 run on Linux OS (Operating System) Ubuntu Mate (16.01 Xenial). The reason of using Ubuntu Mate is because of the suitability of using ROS is with Linux OS. ROS provides libraries and tools to help software developers create robot applications. It provides hardware abstraction, device drivers, libraries, and more. ROS provides libraries for RPLIDAR so that Raspberry Pi 2 can be integrated with RPLIDAR. In the libraries show step by step on how to configure the RPLIDAR to be working and display data such as angle, distance of the object or surrounding.

Communication between Raspberry Pi 2 and Arduino Mega, and the movement of the robot

The reason behind using two different kind of controller is to differentiate the task for each controller. Raspberry Pi 2 is a controller to integrate, to gather input from RPLIDAR. While Arduino Mega is for control the motor. Therefore, in order to make two controllers to be working as one, there will need a serial communication between them. In GitHub, which is a platform that gather a lot of libraries, example, solution and etc especially for robotics, there are libraries for the communication between Arduino Mega with Raspberry Pi 2 which called *PyCmdMessenger*. It communicates Python with Arduino IDE using *CmdMessenger* serial communication libraries. The libraries give input and output from Arduino to Python and reverse and change the types. So, in this section will discuss on how the communication between Arduino IDE and Python done.

3. RESULTS AND DISCUSSIONS

Integration of RPLIDAR and Raspberry Pi 2

Integration between RPLIDAR and Raspberry Pi 2 is to gather information, data of the distance or angle from RPLIDAR to surrounding. To gather the information, two applications were used. One of the applications is RVIZ which is 3D visualization for ROS. Since the Raspberry Pi 2 used Ubuntu Mate as OS, ROS was installed in order to use RVIZ. The data gather from RPLIDAR can be seen in RVIZ. Red line in RVIZ show that there is obstacle around of RPLIDAR.

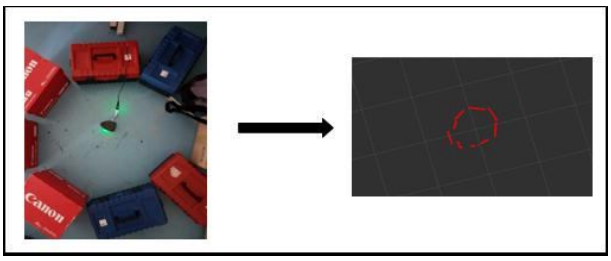

Figure 6: Obstacle view via RVIZ

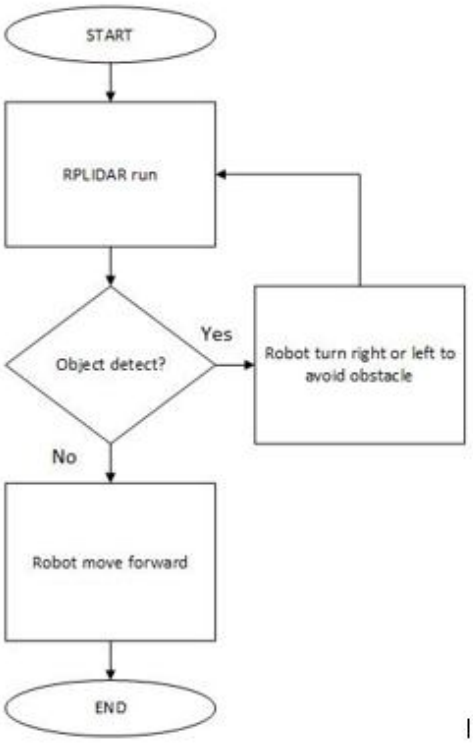

Figure 5: Flow chart of obstacle avoidance robot

Integration of Raspberry Pi 2 with Arduino Mega to move Robot

2nd integration in this project is between Raspberry Pi 2 and Arduino Mega to move the robot. As stated in methodology, it uses Python and Arduino IDE, also with the help of *PyCmdMessenger* in GitHub libraries. There are three stats that makes the robot to move which is to move forward, to turn left and to turn right. When there is no obstacle ahead, the program will send to 'Drive direction=0'. This means that the robot will move forward with the given speed = 40, and steering correction of = 10.

When there are obstacles detected in right side of the robot, the Drive direction will show the opposite value as the angle of obstacle detected. In this figure below, the angle of obstacles detected by RPLIDAR is around 180 to 270 degree. Therefore, the Drive direction will be around 90 to 179 to avoid the obstacles. By getting the drive direction, the calculation will be done for giving certain speed to each motor. Below the drive direction, the order is (motor speed, left wheel, right wheel). The value of speed for right wheel and left wheel will be same but in opposite polarity to make the robot turn. The negative polarity for the motor going forward while positive for motor going backward. The value inside the integer will be send to Arduino then the output from Arduino will do their works to move the robot.

The equation for speed of each motors is

$$Left\ Wheel\ (Speed) = Left\ Wheel + Speed,$$

and

$$Right\ Wheel\ (Speed) = Right\ Wheel + Speed.$$

Figure 7 shows the testing on the robot movement straight (without obstacle), obstacle on the right so the robot will turn left, and obstacle detected on the left.

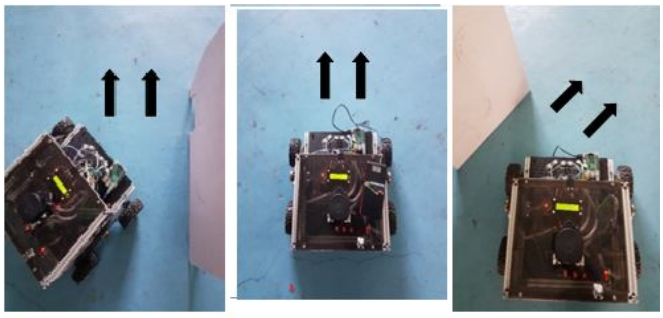

Figure 7: Robot movement in 3 situations

Table 1 shows the speed given for each motor for turn the robot to left. By referring this table, the right wheel speed is higher than left wheel speed and this makes the robot to turn left and avoid the obstacle.

For turning the robot to move to the right, the angle of obstacles that been detected by RPLIDAR will be around 90 to 179 degree. Therefore, the drive direction will be around 180 to 270 degree. The calculation for getting the speed value for each motor is the same. The only different is the polarity for left wheel and right wheel is inverse. This shown that the direction of the robot is different which will turn to right because the speed for left wheel is higher than right wheel.

Table 1: Speed given to motor for Turn Left

Speed	Left Wheel (Speed)	Right Wheel (Speed)
40	-10.5	90.5
40	-17.0	97.0
40	-20.0	100.0
40	-4.5	84.5
40	-6.0	86.0
40	-20.5	100.5
40	-6.5	86.5

Table 2: Speed given to motor to Turn Right

Speed	Left Wheel (Speed)	Right Wheel (Speed)
40	18.0	-18.0
40	18.5	-18.5
40	18.0	-18.0
40	18.5	-18.5
40	18.5	-18.5
40	18.5	-18.5

Overall findings for obstacle avoiding robot using RPLIDAR are successful.

4. CONCLUSIONS

It is concluded that this project has reached its objective after several test and correction been made. The integration of RPLIDAR with Raspberry Pi 2 allows the robot to see the surrounding and detect obstacles when meet one. But there is limitation for Raspberry Pi 2 to gather and record the surrounding in case for doing mapping since its need to implement ROS in overall. Therefore, the robot is not able to do localization and mapping. The integration between Raspberry Pi 2 and Arduino Mega able the Arduino to read the command given from Raspberry Pi to move the motor. After a few testing's, the robot can turn well and avoid obstacle in given space. It can conclude that this can be another way for integrating RPLIDAR for obstacle avoidance purpose.

5. FUTURE WORKS

For future improvement, this project can be upgrade by give the robot the ability to avoid obstacles then back to course. With the help of GPS and the ability of RPLIDAR for knowing the distance and angle, the possibility can be tested. The calculation can be made for letting the RPLIDAR know at what point that the robot will turn and avoid obstacle and back to the course again.

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