Development of a Mobile Platform with IoT for LIDAR

Tew Chin Keong, S.A.A. Shukor*, N.A. Rahim

Faculty of Electrical Engineering Technology, Universiti Malaysia Perlis, 02600 Perlis, Malaysia

*shazmin@unimap.edu.my

Abstract. Nowadays, interior scanning is very significant in mobile robot applications because it helps humans to monitor, study and investigate the environments, especially the challenging ones with clutter, hazardous, unexplored, dynamic, and others. A LIDAR can be utilised to perform the task; however, suitable mobile platform should be accompanying it to allow mobility while collecting data representing the environment. This paper shows the process of developing a suitable mobile platform for a low-cost laser rangefinder, RP LIDAR from SLAMTEC with its scanning performance. The mobile platform used in this project is an Arduino Uno R3 4WD mobile robot. L298 H-Bridge IC and HC-05 Bluetooth module is implemented on the robot to make the user able to control its movement through a mobile application. MIT app inventor is used to develop the mobile application. Through the application, user can control the mobile robot with the LIDAR to move around the selected indoor area to scan its environment. To show the scanning results, MATLAB will be used to plot the map. Analysis from the plotting show good mapping results and similar to the real environment, thus presenting its potential to be used in the above-mentioned situations.

1. Introduction

Robotic research is a big area and it involves a large area of different technologies, applications, and engineering. One of the important technologies is mobile robotics and has been used for solving various tasks from assisting nurse in hospital environment [1] to carrying out hazardous duties in a confined space [2]. A mobile robot is also utilised for scanning and mapping interiors to solve various related issues such as indoor modelling development for Architectural / Engineering / Construction (AEC) applications [3]. Adequate scanning and mapping are needed, thus a light detection and ranging sensor, or LIDAR can be integrated. LIDAR is a remote-sensing technology that uses pulsed laser energy (light) to measure ranges (distance) [4]. It is preferred compared to other sensing technology like ultrasonic and camera [5]. However, its limitation especially in the price has make it prohibitive to some.

An RP LIDAR is a low-cost laser rangefinder, 360-degree 2D laser scanner solution. There are a lot of versions of RP LIDAR such as RP LIDAR A1M8, A2M4 and A3M1. In this project, the RP LIDAR A2M8 is used to perform the scanning process. It is the latest generation low-cost 360 degrees 2D laser scanner developed by SLAMTEC. It can take up to 8000 samples of laser ranging per second with high rotation speed. This system can perform the scanning in 360 degrees with a maximum scanning range of 12 meters. It has a scanning frequency of 5.5 Hz when sampling 360 points each round and it can be set to a maximum of 10 Hz. RP LIDAR uses high-speed vision acquisition to calculate distance using a laser triangulation ranging concept. It works by emitting a modulated infrared laser beam, which is subsequently reflected by the item to be detected. A vision acquisition system in the RP LIDAR samples the returning signal. The RP LIDAR's DSP then begins processing the sample data and outputs distance.
and angle values between the item and the RP LIDAR via its communication port [6]. However, for portability and mobility, the LIDAR needs to be integrated with a suitable mobile platform.

The aim of this work is to develop a suitable mobile platform in assisting the LIDAR to access respective environment to perform data collection. An appropriate controller needs to be accompanying it so that it able to be navigated and manoeuvred easily. Although exist similar work, some used other sensors like Kinect [7], while others utilised normal connections to control the robot and data transfer [5] [8]. This project also utilised Internet-of-Things (IoT) through mobile applications to control and transfer the data.

2. Methodology

Figure 1 shows the block diagram displaying the overall developed system and how it works. The power supply will be connected to the LIDAR and Arduino. LIDAR will transfer data to the laptop through IoT platform. MATLAB will be used to process and produce the map of the scanned environment. A suitable mobile application is developed to control the movements of the robot.

In allowing mobility to the LIDAR, a suitable platform can be integrated. In this project, the Arduino Uno R3 4WD mobile robot is used to manoeuvre the RP LIDAR to move in the selected indoor area. It is chosen because of its simple mechanical structure and very easy to install. It consists of a mobile part (Arduino Uno, rubber wheels, and DC motor), power supply, smartphone, and Bluetooth module [9]. This mobile part involves a driver motor and four DC motors. The power supply is separated into two different parts which support the mobile part and LIDAR. Figure 2 shows the LIDAR with the mobile robot developed in this work.
Figure 2. The developed mobile robot with LIDAR

The RP LIDAR will first be installed on a mobile robot, which will be controlled by a mobile application. The user will use the application to command the mobile robot to move and stop at a location, before the LIDAR begin to scanning. Figure 3 shows the configuration of the application.

Figure 3. The accompanying mobile application to control robot’s movements

Then, the data from the RP LIDAR which are distance and angle will be received by Arduino Mega and delivered to NodeMCU, which will then send and save in the Firebase database. The data from Firebase will then be imported into MATLAB to create the 2D mapping. Figure 4 shows the connection of NodeMCU to Arduino Mega. To analyse the performance of the developed system, the map will be compared with the real measurement.
Figure 4. Connection of NodeMCU to Arduino Mega

3. Results and Discussion
Figure 5 shows the selected indoor environment for this work, a room with 4 m x 4.5 m dimension. Four random locations were chosen in collecting full data representing the room as shown in the figure (point 1 – 4). Figure 6 shows the individual scanning from each point, whereas Figure 7 shows the registered data representing the overall scanning of the room. It can be seen that the results plotted in MATLAB resembles the environment qualitatively.

Figure 5. The selected indoor environment to be scanned
To further analyse the developed system in scanning and mapping the environment, random location within the environment is chosen and the measurement from the map is compared with the real ones. Error of differences between the measurements are also calculated. Figure 8 highlights the selected points, and Table 1 summarizes the results. It can be seen here that the system able to map the
surroundings with 97.8 % accuracy, which shows the capability of the developed system in performing the task.

![Figure 8. The chosen random locations with respect to the imaginary origin](image)

**Figure 8.** The chosen random locations with respect to the imaginary origin

| Point | Distance between the origin and the point (Real measurement) (mm) | Distance between the origin and the point (MATLAB measurement) (mm) | Accuracy (%) |
|-------|---------------------------------------------------------------|---------------------------------------------------------------|--------------|
| 1     | 770                                                          | 793.00                                                        | 97.01        |
| 2     | 1190                                                         | 1120.00                                                       | 94.12        |
| 3     | 1930                                                         | 1929.19                                                       | 99.96        |
| 4     | 1810                                                         | 1836.00                                                       | 98.56        |
| 5     | 1790                                                         | 1887.43                                                       | 94.56        |
| 6     | 4690                                                         | 4737.68                                                       | 98.98        |
| 7     | 4160                                                         | 4166.80                                                       | 99.84        |
| 8     | 3750                                                         | 3776.08                                                       | 99.30        |
| 9     | 2060                                                         | 2013.86                                                       | 97.76        |
| 10    | 1160                                                         | 1184.35                                                       | 97.90        |
| **Average** | **97.80**                                                   | **97.80**                                                     |              |

Based on the findings, it appears that the employment of the RP LIDAR with its accompanying developed mobile platform able to achieve excellent scanning accuracy. As can be seen from the table,
all measurements able to show above 90% accuracy. However, suitable processing method should be applied in scanning and mapping limited and small areas. Furthermore, proper planning in data collection is needed to ensure correct and adequate data for mapping.

4. Conclusion and Future Work
In conclusion, a mobile platform for RP LIDAR has been successfully developed. However, further work including the development of an appropriate, accompanying algorithm to scan and map the surroundings is important. In the hardware point of view, Raspberry Pi could also be used, as user can install and use the SDK software in Raspberry Pi directly to collect the data from RP LIDAR, which can minimize the error during data collection.

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