Evolution in Electrical and Electronic Engineering Vol. 3 No. 1 (2022) 349-356

EEEE

Homepage: http://publisher.uthm.edu.my/periodicals/index.php/eeee
e-ISSN : 2756-8458

Laser-based Autonomous Navigation of Lawnmower

Nur Adlina Shahirah Abdul Rahim[1], Abu Ubaidah Shamsudin[1]*

[1]Faculty of Electrical and Electronic Engineering,
Universiti Tun Hussein Onn Malaysia, Parit Raja, Batu Pahat, 86400, MALAYSIA

*Corresponding Author Designation

DOI: https://doi.org/10.30880/eeee.2022.03.01.039
Received 24 January 2022; Accepted 01 March 2022; Available online 30 June 2022

Abstract: Manual lawn mowing is a minor and difficult task that necessitates a long working hour in the sun and rain. The goal of this study is to create an autonomous lawn mower robot. This article shows the development process for a lawnmower robot, starting with 3D CAD hardware design in Solidworks, simulating the 3D cad design in Gazebo simulator, and incorporating autonomous navigation into the simulator using Robot Operating System. Gmapping, a well-known LIDAR-based SLAM method, is used to evaluate the reliability and accuracy of the autonomous lawnmower in the simulator for autonomous robot verification in terms of Simultaneous Localization and Mapping. The average accuracy of SLAM relative to ground truth is 98.4 percent for the x-axis and 98.86 percent for the y-axis.

Keywords: Lawnmower, Robot Operating System, Gazebo Simulator

1. Introduction

In recent years autonomous lawnmowers are a growing trend of home appliances that take the hassle out of daily chores. The function is similar to autonomous vacuum cleaners in that they clean dirty floors without the need for human intervention, but they take care of your lawn. The mowing robot aims to preserve the lawn's turf health and aesthetics on its[1]. This project proposed a self-navigating mower that is fitted with a LIDAR sensor. The main challenge is to navigate in a large open space.

Mapping the mowing area necessitates a solid position approximation., so the mower will not take the same direction again, avoid obstacles and accomplish the goal [2]. Maps are used to provide knowledge about the environment to the vehicle's system using SLAM (Simultaneous Localization and Mapping). SLAM is an environment mapping and also localization tool [1]. A LIDAR SLAM localization system is implemented in a ROS software framework, with Cartographer SLAM and the adaptive localization algorithm [3] LIDAR sensor, Inertial Measurement Unit (IMU), and odometer sensor are used to construct the mobile robot model. The sensor gathers environmental data as well as the mobile robot's displacement data [4]. Obstacle avoidance is designed with obstacle detection and

*Corresponding author: ubaidah@uthm.edu.my

collision-free motion planning in mind. IMU and Ultrasonic scanning sensor are used in the construction of this mobile robot. In comparison to a LIDAR sensor, an ultrasonic sensor provides inaccurate measurements [5]. Most autonomous lawnmowers employ an area wire emitting an electromagnetic field for boundary definition to operate [6]. Inside the wire, navigation is often random, which is simple and reliable but takes longer to cover the entire lawn than systematic movement [6].

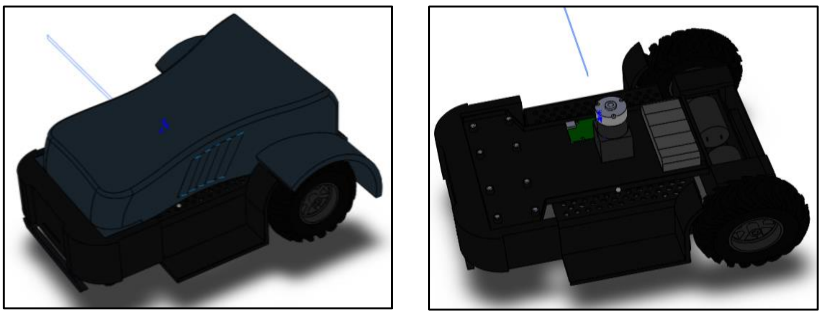
The autonomous lawn mower will be using ROS (robot operating system) to map and navigate. ROS is a software library that aid in the development of robot applications. The robot will discover the virtual universe on its own and build a 2D map of it. After that, an effective navigation strategy is implemented [7]. With ROS, It is possible to obtain hardware abstraction of a robot autonomous vehicle utilized in the project, as well as sensors, motors, and actuators that may be used in navigation, using the ROS inform of URDF, XACRO, and Meshes files. Gazebo and RVIZ are two more open-source programs that are utilized in ROS. A gazebo is a simulation program that allows a robotic engineer to construct a virtual environment in which a robot may be simulated. To guide the robot towards subjective targets and Gazebo simulator. Gazebo simulations are robot simulations created with Gazebo, a 3D simulator capable of accurately and capably simulating robot populations in complex indoor and outdoor environments. ROS was used as a navigational aid during this autonomous navigation. the platform for tracking and evaluating the robot's motion SLAM (Semantic Link Analysis Method).

2. Materials and Methods

2.1 Hardware Design

This hardware design is created in SolidWorks software and it designed part of chassis then followed by wheel and rim, caster wheel, mower blade, Brushless motor, blade cover, and body casing and it fully represents the objective which is to develop modeling for Gazebo. This autonomous lawnmower was simulated in a robot operating system (ROS) and also 3D simulation in the Gazebo simulator to get the accuracy position of two simulators.

Figure 1 shows a design of an autonomous lawnmower using SolidWorks software that was designed part by part with a highly durable and wide size surface chassis to support the robot. The lawnmower wheel has been imagined as a foam rubber wheel that worked on flat and slopes areas. The lawnmower wheels made it easier for the mower to work in a difficult place. In front of the robot, the caster wheel is designed at 360-degree rotation to making easier for the autonomous lawnmower to move. For safety reasons, below the robot, the blade has been designed to slide inside when the mower is turned off and out when the mower is switched on. It has been made as a safety implement for humans and their surroundings. The casing was intended to protect a component within the mower from rain, sun damage, and anything else that could harm the component and cord inside the autonomous lawnmower and constructing a louver on both sides it will ensure that the component and motor inside the body do not overheat.



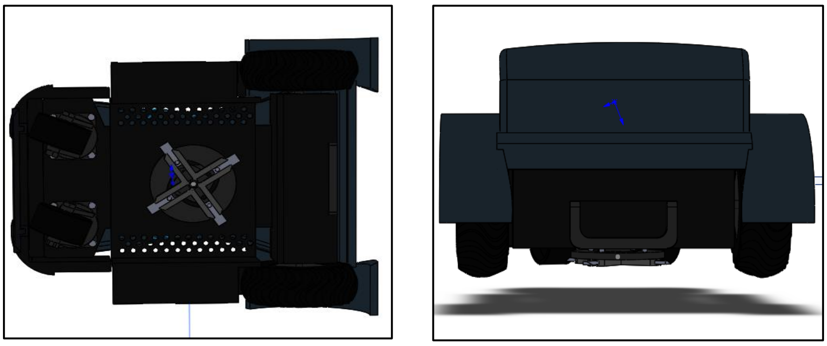


Figure 1: Project design

2.2 Simulation in ROS and Gazebo Simulator

Through specific packages, the Gazebo simulator can link directly to the ROS. These packages contain the interfaces required to mimic a Gazebo robot utilizing ROS command and dynamic reconfiguration. To get the connection with the robot, ROS requires a description of the robot's kinematics in URDF (Universal Robot Description Format) files from SolidWorks files to interact. The Gazebo is a 3D simulator, while ROS is the robot's user interface. When both software is combined, it will get the best robot simulation. Gazebo to construct a 3D scenario on your computer that includes robots, obstacles, and a variety of other items. This allows for an easy comparison of their actions and work.

Figures 2 and 3 show the mapping process by running the gmaping_demo.launch and roslaunch turtlebot_rviz_launchers view_navigation.launch in the terminal followed by the launch of the teleop keyboard. The teleop keyboard is used to control the robot for the mapping process. Save the map with the command rosrun map server map saver –f map name> in the terminal and then do the roslaunch turtlebot_gazebo amcl_demo.launch map_file:=/home/adlina/map1.yaml to open the saved map.

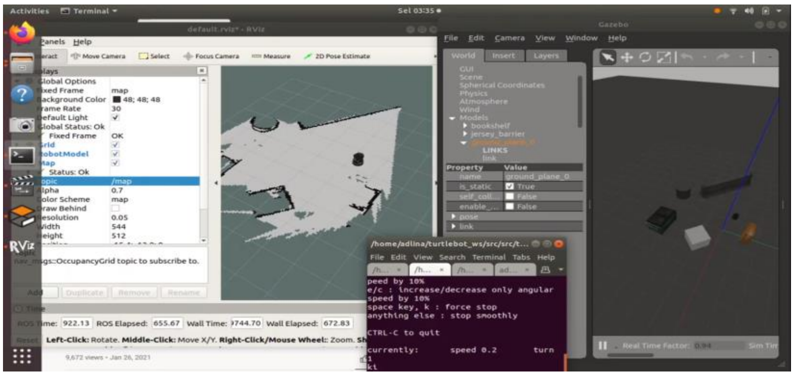


Figure 2: Mapping process in ROS and Gazebo

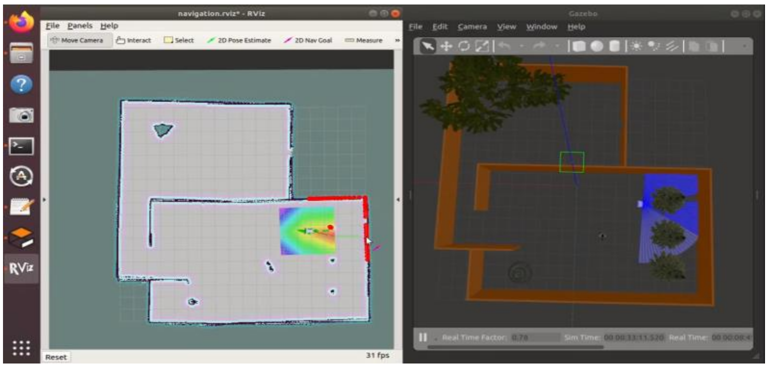


Figure 3: Autonomous navigate using 2D nav goal

2.3 Methods

Robot simulation is the main reason for the development and testing of robot models and it can be tested using a well-designed simulation model as shown in Figure 2 by using SolidWorks software. The ROS is used to developed localization and mapping based on LIDAR Laser based on the SolidWorks URDF. From ROS software, simulate a 3D simulation in Gazebo simulator. The Gazebo platform can correctly and effectively mimic robots in a variety of complicated situations for both indoors and outdoors that considerably higher level of realism. Figure 4 shows the work flow of this project.

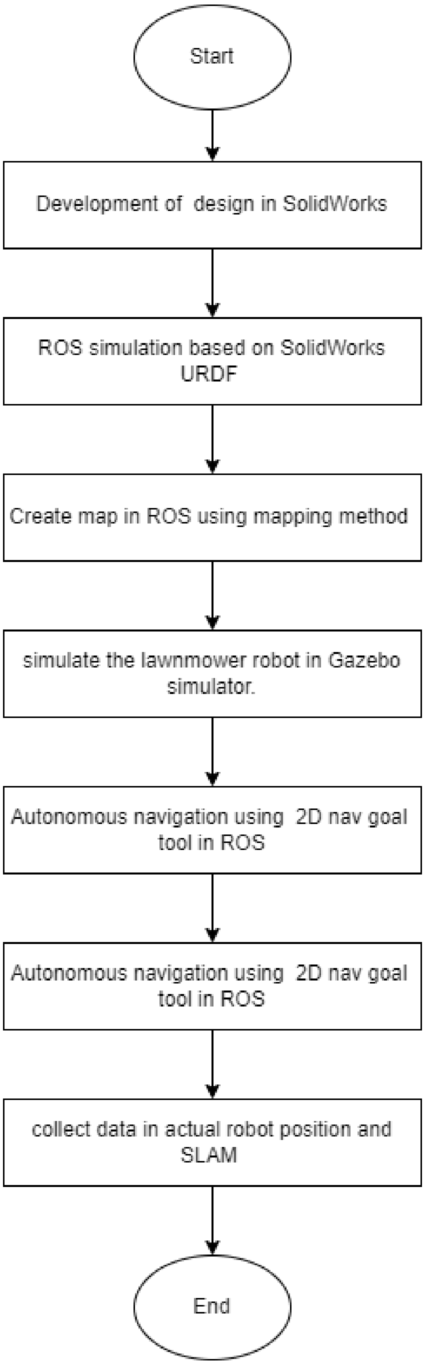


Figure 4: Work flow of the project

3. Results and Discussion

This section presents the expected results and discussion on the developed system. It is expected that the findings all the objectives of this study by engaging in design and software simulation. The project performed whether the robot could navigate the map on its own without or with obstacles. The robot could detect obstacles and avoid them by adding a LIDAR sensor and programs.

3.1 Results

Figure 5 and 6 show 1118 results of post accuracy of robot location in map and Odom. Based on the graph there was an error between the SLAM result and the actual robot position. As reported by the simulator, Map is the SLAM result while the actual robot position is represented by Odom. The purpose of comparing the SLAM output to the actual robot position is to assess the SLAM's performance in SLAM accuracy. To get the accuracy of the robot location the calculation has been made using the equation below to show the achievement of the accuracy.

$$\text{Accuracy} = 100\% - \text{Error Rate}$$

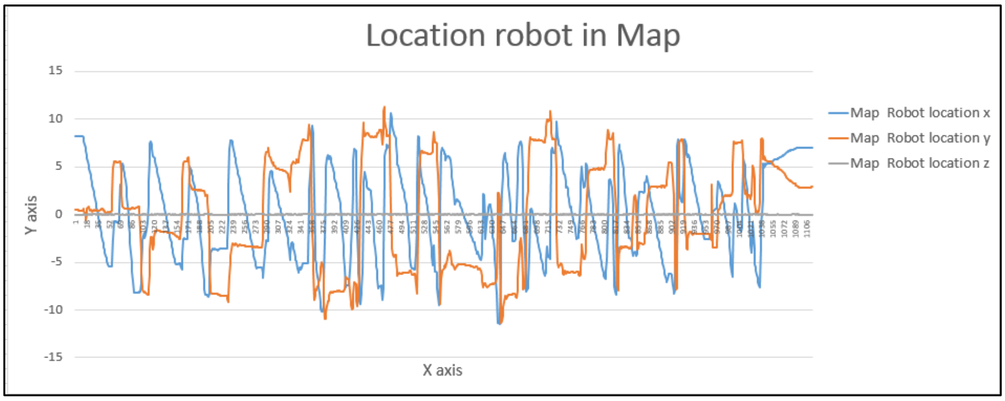


Figure 5: SLAM graph output

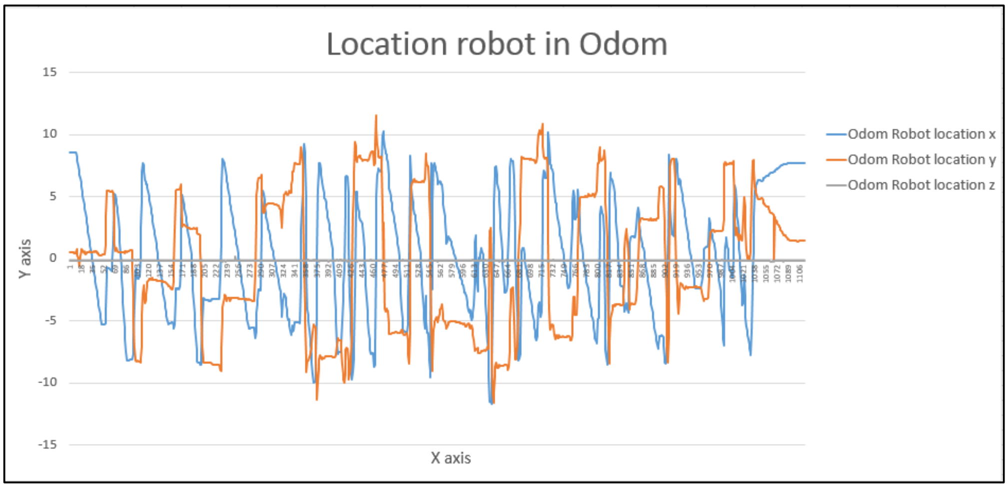
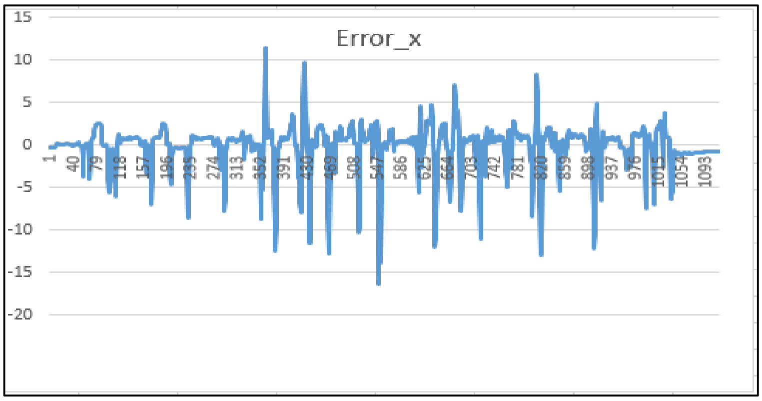


Figure 6: Odom graph output

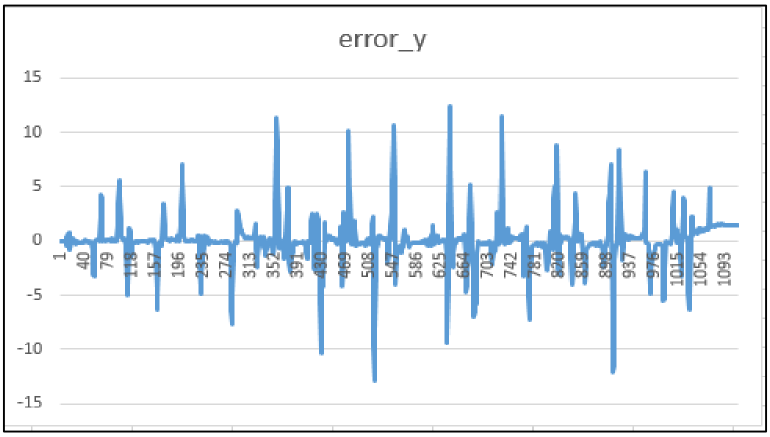
Error_x= slam_x – ground_truth_x(odom)

Based on Figures 5 and 6, there is the output error that has been collected from SLAM output and real robot positions of x and y.

In Figures 7 and 8, the output for both SLAM and real robot position was then separated into two axes x-axis in SLAM and real robot position, and the y-axis in SLAM and real robot position. Figures 7 and 8, will clearly show the accuracy and error location between Map and Odom of x and y.

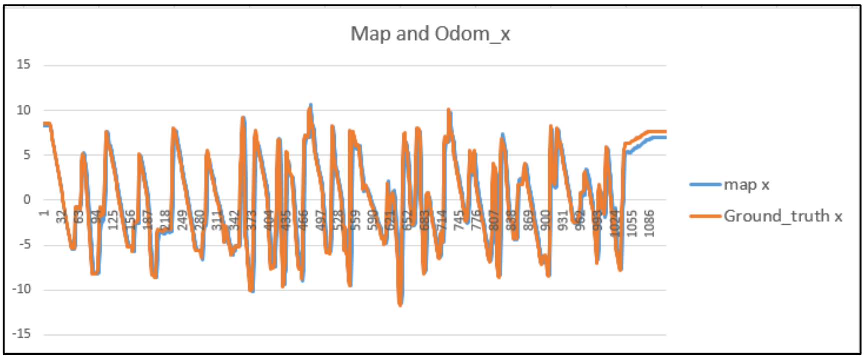


(a)

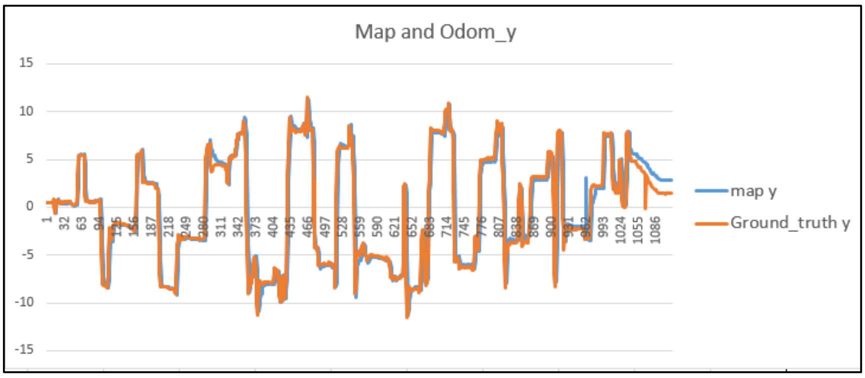


(b)

Figure 7: (a) error of x and (b) error of y



(a)



(b)

Figure 8: Result from SLAM and Odom of x and y

To get the accuracy of robot position, calculation of error on x and y has been made using the formula and the average percent of inaccuracy has shown in Table 1. The average error of x is -0.17427, y is 0.071242 and z is 0.154083. Therefore, the average of the accuracy between SLAM and actual robot position for x is 98.40354, y is 98.86807 and z is 99.84563.

Table 1: Average of accuracy and error of SLAM and actual robot position

Average of accuracy			Average of error		
X	Y	Z	X	Y	Z
98.40354	98.86807	99.84563	-0.17427	0.071242	0.154083

4. Conclusion

This project is about a lawnmower robot using SLAM for map creation and navigation in a simulation with an environment using a LIDAR laser. Create a lawnmower robot design in SolidWorks, then use ROS and Gazebo to perform autonomous navigation. In mapping, to avoid the robot not recognizing the map, place any obstacle in the map, but avoid putting any moving object. After completing the design and mapping process, the lawnmower robot's capacity to perform autonomous navigation has been tested. In this project, the robot has been placed in an outdoor environment, which is a grass park for autonomous lawnmower robot. As a result, the final result was divided into three halves, one of which was used as data to help find the robot's accuracy.

Acknowledgement

The authors would like to thank the Faculty of Electrical and Electronic Engineering, Universiti Tun Hussein Onn Malaysia for its support.

References

[1] J. Yang, S. J. Chung, S. Hutchinson, D. Johnson, and M. Kise, “Vision-based localization and mapping for an autonomous mower,” *IEEE Int. Conf. Intell. Robot. Syst.*, pp. 3655–3662, 2013, doi: 10.1109/IROS.2013.6696878.

[2] H. Liu, Z. Yuan, and Z. Su, “Design and realization of visual wireless autonomous lawn mower based on machine vision,” *2014 11th Int. Comput. Conf. Wavelet Act. Media Technol. Inf. Process. ICCWAMTIP 2014*, pp. 353–358, 2014, doi: 10.1109/ICCWAMTIP.2014.7073425.

[3] M. Franzius, M. Dunn, N. Einecke, and R. Dirnberger, “Embedded Robust Visual Obstacle Detection on Autonomous Lawn Mowers,” *IEEE Comput. Soc. Conf. Comput. Vis. Pattern Recognit. Work.*, vol. 2017-July, pp. 361–369, 2017, doi: 10.1109/CVPRW.2017.50.

[4] D. Chikurtev, “Mobile Robot Simulation and Navigation in ROS and Gazebo,” *2020 Int. Conf.* Autom. Informatics, ICAI 2020 - Proc., pp. 2–7, 2020, doi: 10.1109/ICAI50593.2020.9311330.

[5] C. Marshal Revanth, D. Saravanakumar, R. Jegadeeshwaran, and G. Sakthivel, “Simultaneous Localization and Mapping of Mobile Robot using GMapping Algorithm,” Proc. - 2020 6th IEEE Int. Symp. Smart Electron. Syst. iSES 2020, pp. 56–60, 2020, doi: 10.1109/iSES50453.2020.00024.

[6] M. Franzius, M. Dunn, N. Einecke, and R. Dirnberger, “Embedded Robust Visual Obstacle Detection on Autonomous Lawn Mowers,” IEEE Comput. Soc. Conf. Comput. Vis. Pattern Recognit. Work., vol. 2017-July, pp. 361–369, 2017, doi: 10.1109/CVPRW.2017.50.

[7] Y. Alborzi, B. S. Jalal, and E. Najafi, “ROS-based SLAM and Navigation for a Gazebo-Simulated Autonomous Quadrotor,” 2020 21st Int. Conf. Res. Educ. Mechatronics, REM 2020, pp. 1–5, 2020, doi: 10.1109/REM49740.2020.9313875.