EVOLUTION IN ELECTRICAL AND ELECTRONIC ENGINEERING
e-ISSN: 2756-8458

EEEE

Vol. 5 No. 1 (2024) 575-580
https://publisher.uthm.edu.my/periodicals/index.php/eeee

Ros Based Slam Implementation for Speech Recognition Autonomous Navigation Dim Sum Trolley

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DOI: https://doi.org/10.30880/eeee.2024.05.01.073

Article Info

Received: 22 June 2023
Accepted: 31 March 2024
Available online: 30 April 2024

Keywords

ROS, SLAM, Speech Recognition, Autonomous Navigation

Abstract

The Dim Sum Trolley is commonly used in restaurants or tea pavilions to serve dishes. However, a large amount of manpower is needed to push the trolley as well as serve the food. Therefore, an artificial intelligence or portable food trolley has been proposed, in which the food trolley can move autonomously according to voice commands and input commands from the touchpad. The goal of this project is to design and develop an autonomous Dim Sum trolley based on ROS and Gazebo, and the scope of the project can be divided into three scopes: URDF-customized robot, software development using ROS (Robot Operating System), and Gazebo simulator software. This project is conducted fully in simulation with SLAM technology and the ROS operating system, with the URDF robot first being drawn in Fusion 360 and imported into Gazebo software. After that, all the commands and instructions are given to the robots in the gazebo to execute the tasks. From this result of the robot's location, we can observe that the robot can perform according to the commands given. To conclude, the URDF robot can run perfectly with speech recognition; however, some additional improvements can be made for future work, such as integrating temperature monitoring capabilities into the AI robot to ensure food quality and safety.

1. Introduction

Dim Sum, a traditional Chinese dish associated with Cantonese cuisine and commonly used in restaurants [1], is typically served in a bamboo steamer and commonly found in tea pavilions [2]. In the past, tea pavilions often had multiple floors, requiring servers to carefully balance the dishes on their arms or arrange them on trays as they moved up and down the stairs [3]. Eventually, dim sum carts were introduced, enabling servers to use trolleys to serve the steaming dishes and plates. As demand increased, these carts evolved to maintain the temperature or reheat the food, leading to the vital role of mobile robots in this context. Therefore, an autonomous navigation and speech recognition mobile robot is introduced in this paper to solve the problems.

Meanwhile, mobile robots have proven to be valuable across various industries, prompting researchers to conduct extensive studies on their applications [4]. They are employed in space exploration, military operations, medicine, education, and even underwater research. Saksham Jain [5] mentioned that a novel computer vision-based approach for simultaneous localization and mapping (SLAM) is being developed. This approach leverages an extended Kalman filter [6] to effectively generate an environment map and enable autonomous navigation within the environment. The algorithm outlined in the paper efficiently computes the shortest collision-free path towards the desired goal, ensuring obstacle avoidance and enabling successful robot motion planning. Thus, a mobile robot with SLAM technology will be used in the simulation to perform navigation tasks.

ROS offers a set of services that resemble those provided by an operating system, enabling the operation of robots [7]. Based on S. Pramod Thale [8], the ROS depth image processing module is used to transform this depth image into a 3D point cloud. Using the point cloud to laser scan program, this 3D point cloud data is transformed into a 2D laser scan. By giving all of the input parameters to the Gmapping packages in RVIZ, a map is created.

The URDF (Unified Robot Description Format) is an XML file utilized for detailing the structure, joints, and degrees of freedom of a robot model [9]. The virtual representation of a robot must possess all the essential attributes of its real-world hardware counterpart. While the visual appearance of the virtual robot may or may not resemble the physical robot, it must capture an abstract representation that encompasses all the physical traits and characteristics of the actual robot [10].

2. Methodology

This section describes the methodology that is carried out through this paper, which consists of an overview of the project and the software and operating system needed to perform the project.

An operating system is a fundamental software component that acts as an intermediary between computer hardware and user applications [11], while software is a term used to describe a set of instructions, data, or a program that is used to operate computers and carry out specific tasks [12]. The project makes use of a number of different pieces of software to carry out various tasks and commands:

- Linux
- Ubuntu
- ROS Noetic
- Fusion 360
- Gazebo
- RViz

The simulator that will be used to implement this project is called Gazebo. Any ROS-related packages are launched with the Roslaunch command. Before that, a customized robot base will be drawn in Fusion 360 and exported to the world that was created in Gazebo. Next, the robot will scan the virtual restaurant in Gazebo using GMapping and save it in Map Saver. This map will be used by the robot to plot the map's odometry. The robot will use the globe to map the odometry parameters and construct a global plan to go to the target. This data will subsequently be received by the robot's navigation stack. Fig. 1 illustrates the flow of the project. The goal of this project is to develop and design a mobile robot base that can fetch trolleys in a customized virtual environment.

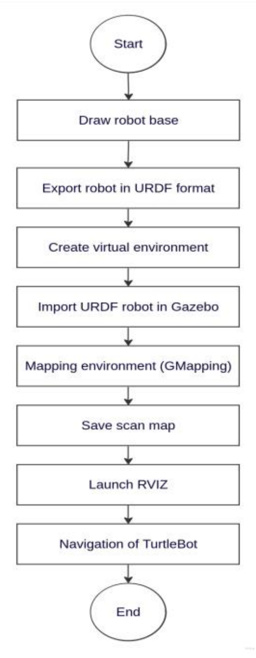


Fig. 1 *Flowchart of the project*

In this project, the robot that is drawn in Fusion 360 is a base to carry three layers of trays to be a DimSum trolley. Fig. 2 shows the robot's base carrying Dim Sum trays as a trolley. Since the name of the part will be used in the coding in Gazebo later, all the parts are named specifically: the left wheel of the robot is named as left_wheel, the right wheel of the robot is named as right_wheel, and the body of the robot is named as base_link.

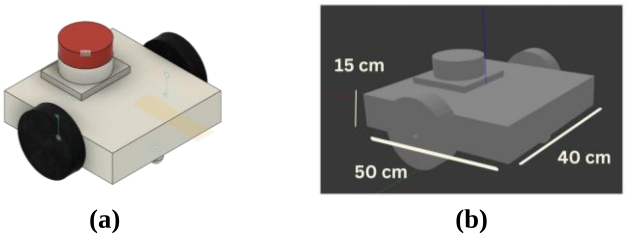


Fig. 2 *Robot base in (a) Fusion 360; and (b) Gazebo*

After the robot is drawn and exported into Gazebo, a virtual restaurant is drawn. After running the robot by teleoperation in the Gazebo, the map was created utilizing the SLAM GMapping method. Some obstacles in the area of the virtual restaurant were shown in Fig. 2, and we can see the TurtleBot has successfully finished mapping to the end point.

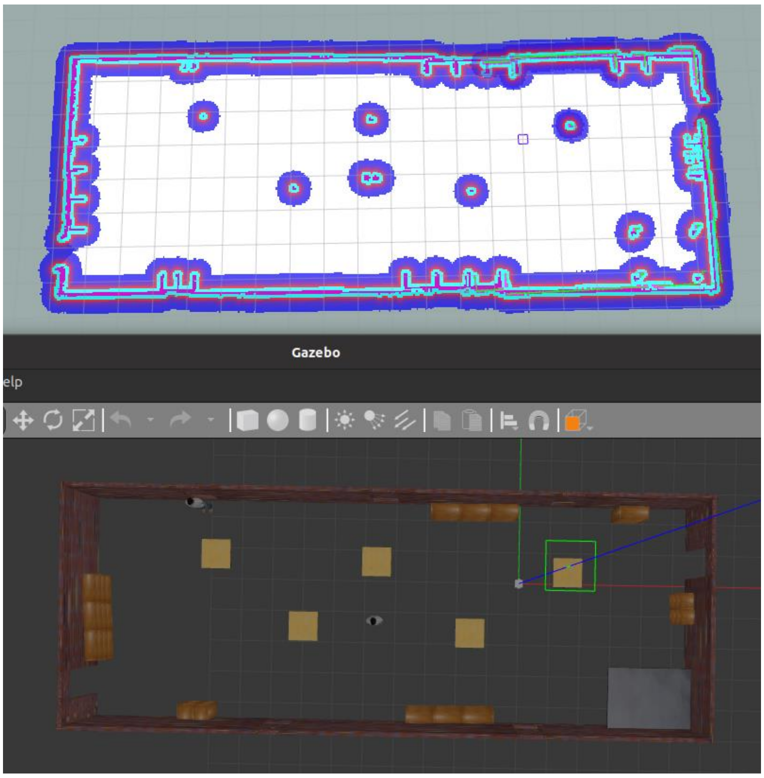


Fig. 3 *GMapping for the virtual restaurant in Gazebo*

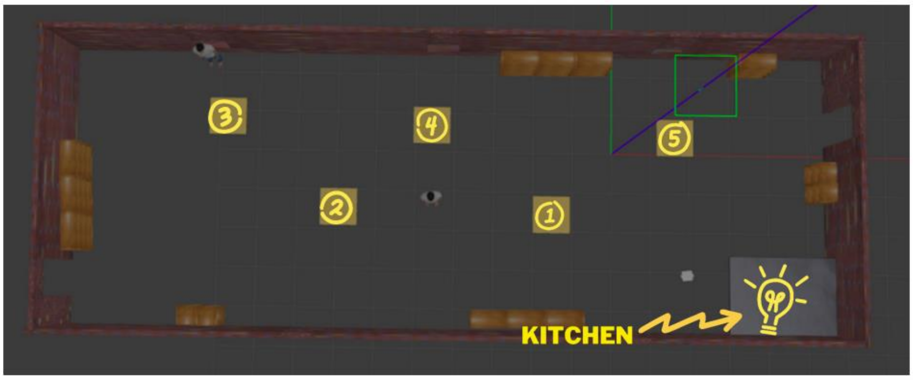


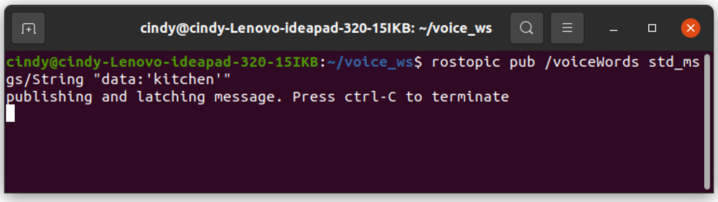
Fig. 4 *Location of tables and kitchen in restaurant*

The DimSum trolley robot base in Gazebo customized virtual restaurant map would move autonomously according to the command given either by voice recognition or from the trolley's touchpad. The locations of tables and kitchen will be as shown in Fig. 3 and Fig. 4. Whilst the navigation for the movement of the trolley base according to the command will be as shown in Table 1.

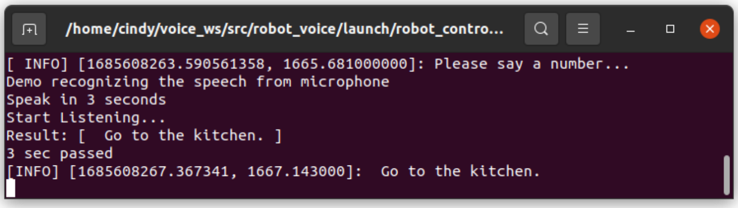
Table 1 *Navigation of Dim Sum trolley*

Command	Destination of Trolley
Number One	Table One
Number Two	Table Two
Number Three	Table Three
Number Four	Table Four
Number Five	Table Five
Kitchen	Kitchen

When the Robot Voice starts to listen to the user's command, it will catch all the keywords as shown in Table 1. For example, either the speaker says "Go to Table One" , "One" , "Number One" or any of the sentences that contain the number of "one", the robot will move to the respective table. The same theory goes to all the dining tables, as well as the kitchen. Based on this, the navigation module is done, for both speech recognition and manual input. Then, the command is input in the terminal as shown in Fig. 5.



(a)

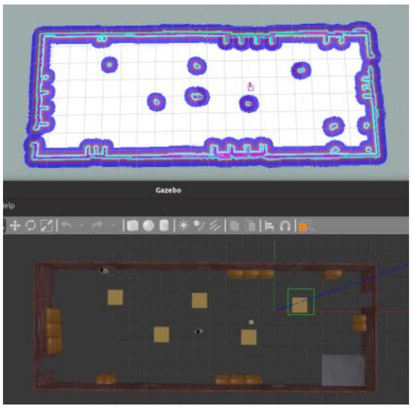


(b)

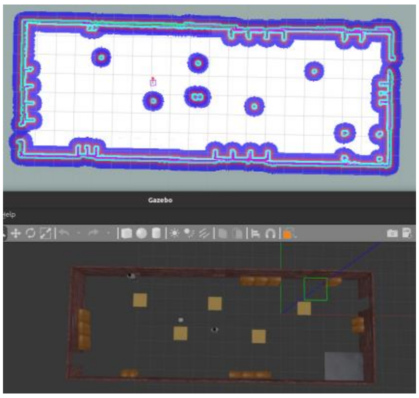
Fig. 5 *Command for (a) manual input; (b) speech recognition*

3. Result and Discussion

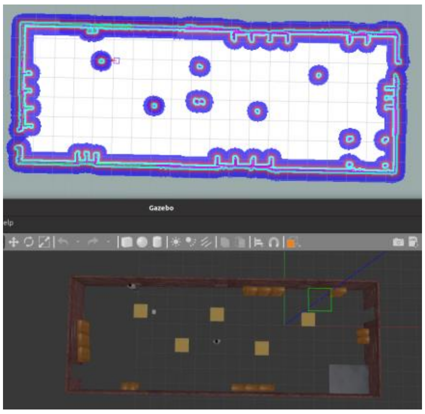
Fig. 6 shows the location of robots at Table One, Table Two, Table Three, Table Four, Table Five and Kitchen according to the commands given by the user.



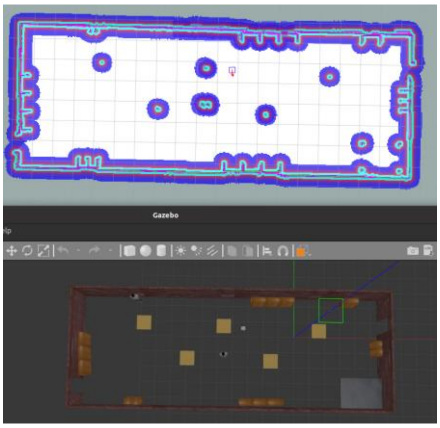
(a)



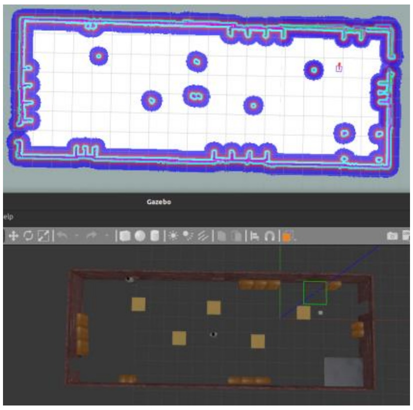
(b)



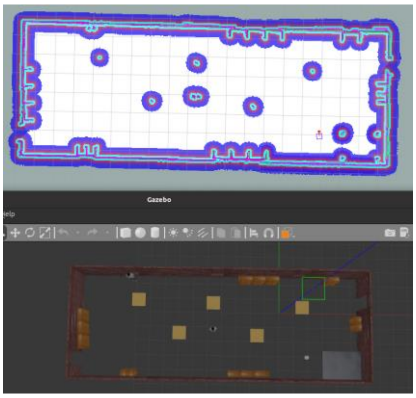
(c)



(d)



(e)



(f)

Fig. 6 *Location of robot at (a) Table One; (b) Table Two; (c) Table Three; (d) Table Four; (e) Table Five; and (f) Kitchen*

4. Conclusion

The project aimed to develop and enhance the capabilities of a URDF mobile robot in Gazebo simulation. The robot was successfully imported into Gazebo, and navigation modules were integrated to enable autonomous navigation within the simulated environment. Furthermore, speech recognition was implemented to allow the robot to respond to spoken commands. The limitations of the project included the need to validate the performance of the robot in real-world conditions, as simulation results might differ from actual scenarios. Additionally, the accuracy of speech recognition could be affected by factors such as background noise and variations in accents or speech patterns.

Recommendations for future work in the project involve leveraging AI technologies to enhance the capabilities of the robot. Instead of solely fetching a food trolley and delivering it to a dining table, the robot can be programmed with AI algorithms to autonomously navigate the kitchen, retrieve food items, and serve them at multiple tables. This expanded functionality would significantly improve efficiency and the overall dining experience.

Acknowledgement

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

Conflict of Interest

Authors declare that there is no conflict of interests regarding the completing of the paper.

Author Contribution

The author attests to having sole responsibility for the following: planning and designing the study, data collection, analysis and interpretation of the outcomes, and paper writing.

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