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Omnidirectional Mobil Robot with Navigation Using SLAM

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HIGHLIGHTS

- A mobile robot that can work in confined spaces was built and implemented.
- Using special wheels called Mecanum Wheels, the designed robot works in all directions without a steering device.
- The robot can identify and map unknown environments and localize itself within this map using SLAM.
- It is possible to develop and update the codes used in the robot's programming easily due to the use of ROS because it is open source.

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ABSTRACT

As mobile robots have become widespread in indoor environments with narrow and crowded corridors, such as institutions, the demand for mobile robots has recently increased, especially for service purposes (homes, hospitals, and nursing homes for the elderly). The most important factor of autonomous navigation is the mobile robot's awareness of its surroundings, with the robot's ability to move from one place to another smoothly and safely in terms of avoiding obstacles. In this paper, a mobile robot with multi-directional wheels was designed to work in indoor environments and narrow corridors. SLAM was used to map the environment in which the robot operates, as well as determine the robot's location within this environment based on the data of the LIDAR sensor. The robot was controlled through the ROS robot operating system. In this research, we conducted a practical experiment for the robot's movement inside a corridor and mapped this corridor by SLAM.

1. Introduction

Robotic engineering impacts society in terms of technology and economics[1]. The inspiration for the robot design stems from the need to create a fatigue-free assistant to assist humans with activities such as arduous and dangerous tasks [2]. The robot is a reprogrammable multifunctional controller designed through variable programmed motions to fulfill a set of assignments [3]. The robot must be able to maneuver independently to allow the moving robot to operate autonomously in those places. The precise location of the robot in its environment must be determined by determining the location and coordinates of the specific environment and its direction to achieve the robot's autonomous mobility. Therefore, in mobile robotics, navigation technology is a big problem [4]. Navigation is a field of study that detects and monitors the movement of a vehicle from place to place [5]. For the autonomous vehicle to navigate, it has to know two things, where it is and where it's going. The latter is easily accomplished by transmitting a series of waypoints to the vehicle that defines the path it is to follow[6]. For decades, the development of autonomous robotic navigation systems has been a topic of interest in the research community. In fact, many commonly used programs have been built and implemented, allowing a robot to move to another point with frequent, verifiable guarantees that the robot does not run into obstacles while traveling [7]. When unfamiliar with mapping conditions and locating a robot, the SLAM (simultaneous localization and mapping) algorithm is one of the most studied topics in robotics. SLAM extracts invisible environments using tools such as laser or kinetic scanners or ultrasound sensors[8]. As for the operating system, the Robot Operating System (ROS) is a popular platform for implementing robots. Official ROS kits are sufficient for most botnet tasks. Moreover, ROS offers an API for developing custom packages or communicating with external applications or equipment, such as interfaces and planners [9]. Researchers prefer ROS because of several benefits. ROS allows researchers to quickly and efficiently perform simulation and real-world studies using Gazebo and Rviz [8].

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Researchers have recently proposed several soft computation approaches to overcome the robot navigation problem and prevent obstacles in different settings. The following summarizes the different computational methods used for robot navigation in various settings.

Zhu and Yang recently suggested a unique neuro-fuzzy device adaptive navigational strategy for robots in unfamiliar surroundings. These researchers developed & applied forty-eight fuzzy guidelines for achieving goals and avoiding obstacles. The paper's authors used the neural network method to fine-tune the fuzzy logic membership value variables [10]. Misono et al. used a mobile electrical chair to introduce and validate the modern application for SLAM algorithms of the moving robotic controlled by a laser control profile, with an outside setting like the IGVC Navigating Competition. The proposed SLAM allows the portable robot to start in an uncertain area and eventually generate an ideal world map using only relative observations and simultaneously estimates the position of the traveling robot via the expanded filter of Kalman to validate the process of SLAM proposed [11]. Yip et al. created an omnidirectional moving robot with Mecanum wheels fitted with an RGB-D camera to collect surrounding information. They used SLAM, a popular technique for getting the robot to recognize the situation by sensing the surrounding environment via RGB-D as the sensor [2]. Algabri et al. developed a mobile robot's navigation ability. To improve the organic operation parameters of the fog controller, they fused fuzzy logic with some other flexible computational technologies like Genetic algorithms and neural networks, as well as improved particle swarming. For these pre-installed soft computing technologies [12]. Kahn, Gregory, and others suggested an extended computing diagram that includes prototype & framework techniques and particular states interpolated among null and prototype models. A navigation model formation diagram that trains using basic pictures is an effective model. Through automobile simulations, he explored the selections for his navigational models, comparing this technique to Q-Learning's one-step and double-step technology. He also evaluated this approach to the real-world RC vehicle. He demonstrated how it could train to traverse a complicated interior environment with just only several hours of self-supervision [13]. Mohanta and Keshari suggested a based-knowledge fuzzy control scheme with a Probabilistic Roadmap (PRM) approach for designing the traveling robot's route and goal search actions in the presence of obstacles. The suggested procedure consists of two components. The first folding creates the quickest way between beginning and target positions in a known crowded world, where PRM is utilized to construct a linear connection between the destination node. The next folding stages are assisted in converting sharp corners into smooth curves around the road. A knowledge-based, seamless rotation system guarantees the right angle of heading, correcting robot positions and directions to achieve local/global objectives [14].

The main objective of this research is to design a mobile robot in all directions that operates a robot operating system that uses (SLAM) with (LIDAR) to draw a map of the place where the robot works as well as the localization of the robot within this map.

2. Research Methodology

SLAM node is responsible for mapping and displaying the mobile robot's position on a map [15]. The mobile robot was controlled in this paper by a ROS composed of several nodes. These nodes contain laser scanner data, which handles communicating with RPlidar laser scanning, allowing a mobile robot to monitor direction. As shown in Figure 1 depicts the overall block diagram of the mobile robot.

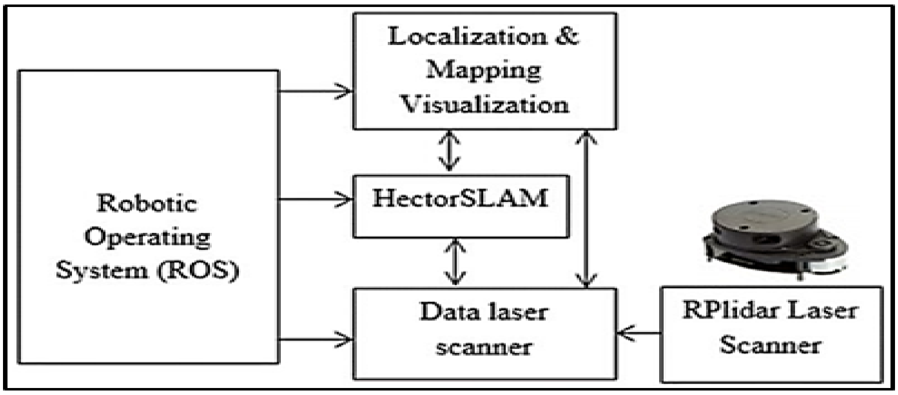
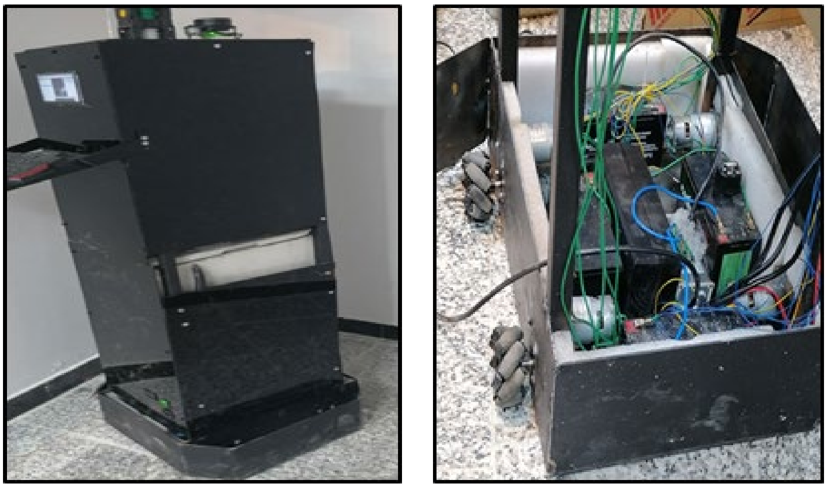


Figure 1: The overall block diagram of the mobile robot

2.1 Hardware Components

The mobile robot in this research, shown in Figure 2, consists of a steel structure with dimensions (0.5 ,0.4 ,1.6) m (length, width, height) that moves with four mechanical wheels that enable the robot to move. In all directions where the mechanical wheels have rubber rollers. These pulleys are distributed around the circumference of the main wheel and tilted at an angle of 45 degrees from the axis of the main wheel [16]. The mecanum wheels are connected to four high torque ASME-MXA DC servo motors, max. 260kgcm, 0.12s-0.24s/60°DC 12-24V. The Raspberry Pi 4 Model B (Pi4B) is used inside the robot's body to control the entire system. It is placed on top of the robot's body RPLIDAR A1M8-R6 360° LASER RANGE SCANNER - 12M RANGE to scan the environment in which the robot is moving. The body of the robot is designed in the form of layers to be used in the distribution of the internal components of the robot as well as to distribute the loads imposed on the robot, as it is used in the process of transporting various things.



(a) **(b)**

Figure 2: Hardware components of the mobile robot

2.2 Software Components

These applications were used for analyzing and communicating with gadgets. The key program in a paper ROS for controlling the mobile robot using the Raspberry Pi 4 microcontroller. ROS requires a Linux operating system on the Ubuntu desktop to run ROS [17]. ROS is used as work processes, interface, storage & tools for programming. The charting is shown on the rviz app, as shown in Figure 3. Automation ROS is a robotic components control system. The ROS consists of individual nodes communicating with the other nodes using the message paradigm post/subscribe. ROS is a versatile foundation for developing robots. This includes tools, modules & protocols intended through a wide range of automated platforms of sophisticated and solid bottoming behaviors.

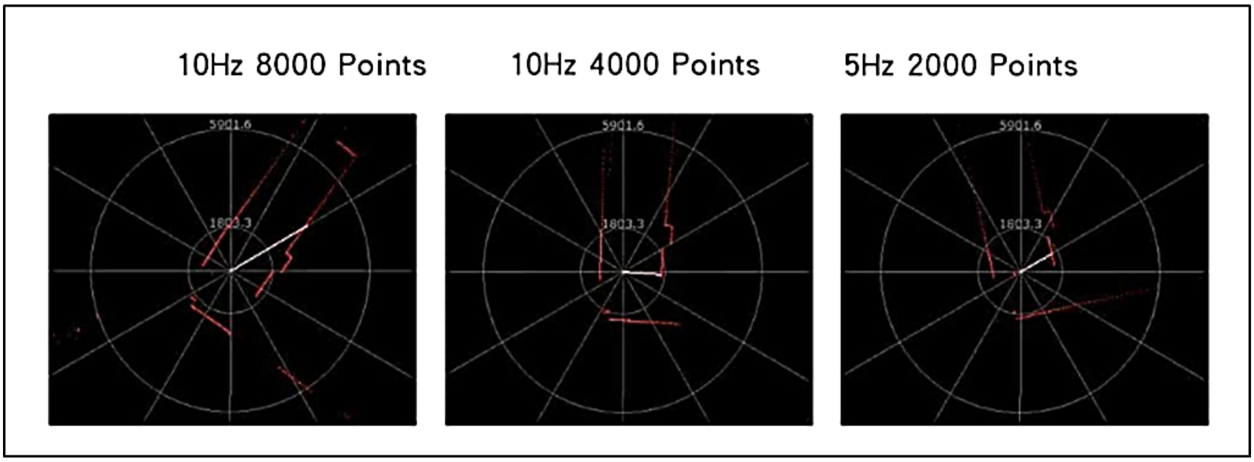


Figure 3: RPLIDAR work (comparison under different conditions)

3. Results and Discussion

The first step is ROS calls for the hardware abstraction layer, which is equivalent to operating systems. However, unlike conventional working systems, it can be used with diverse hardware implementation combinations. In addition, it's for a robotic platform that gives diverse specialized improvement environments for developing robotic utility programs. The LIDAR sample rate determined whether the robot could map faster and more efficiently. The algorithm and optical system of intensive LIDAR have been improved by RPLIDAR, with samples being 8000 times/second higher in LIDAR's economic works, as shown in Figure 3. The scanning frequency of the RPLIDAR ranges from 5.5 Hz to a maximum of 10 Hz in each 360-degree scan cycle. This scanning degree enables it to scan in all directions, and the scan rate can be extended from 2 Hz to 10 Hz, depending on the settings.

The SLAM algorithm was used to create a map of an unknown environment by tracking the robot's location within that environment. The robot was tested inside a narrow lane that was not previously defined for the robot. When the robot is running automatically, the robot's operating system will operate the master node. Thus the LiDAR node, which depends on the data sent by the LiDAR sensor, which is rotating 360 degrees to collect data from the environment where the robot is running and send it to the controller to be processed and set using Rviz tools As shown in Figure (4, 5) shows the real work environment that will be set to evaluate the performance of HectorSLAM. Data from the RPLIDAR A1M8-R6 laser sensor is sent to the ROS.

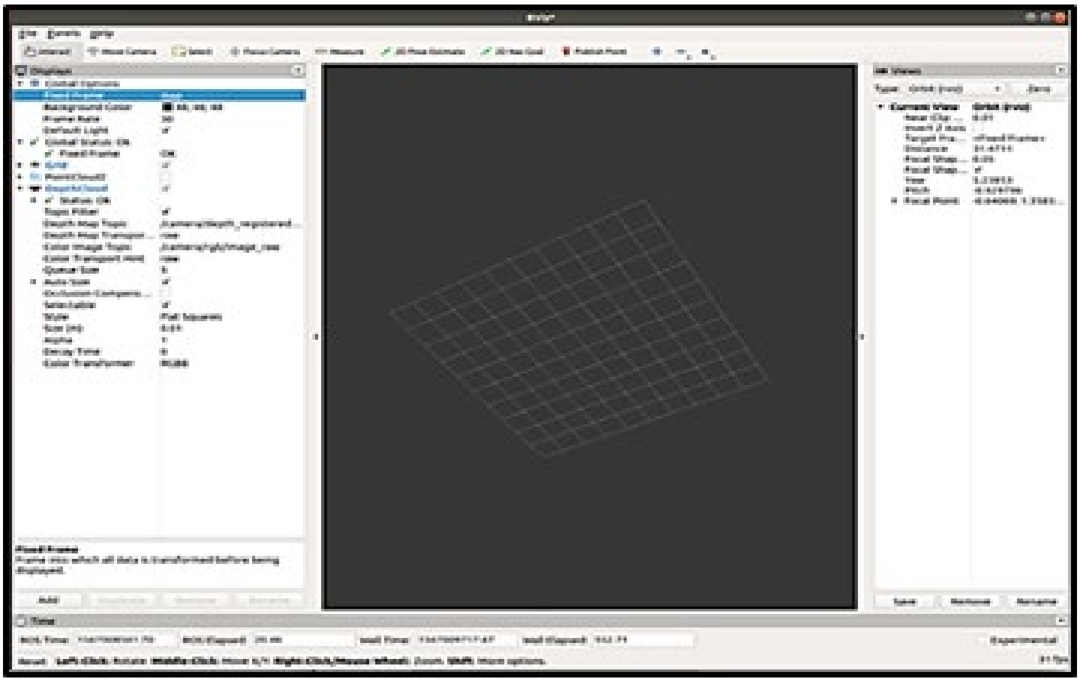


Figure 4: Application for Rviz

Figure 5: Work environment

Figure 6 shows the steps for mapping by HectorSLAM based on data obtained from the RPLIDAR A1M8-R6 laser scanner. When the bot starts working, Rviz starts downloading tools and receives ergonomics data processed according to the SLAM algorithm. All points captured by the sensor are cumulatively stored to form an integrated environment map. The location of the robot is also determined at the same time within this map. These results indicate that the omnidirectional mobile robot with LiDAR can make room maps automatically. The results obtained from the sensors (LIDAR) in the proposed mobile robot and the data representation of these sensors in SLAM. Maps of all previous tests performed by the robot have been obtained, listed in Table 1.

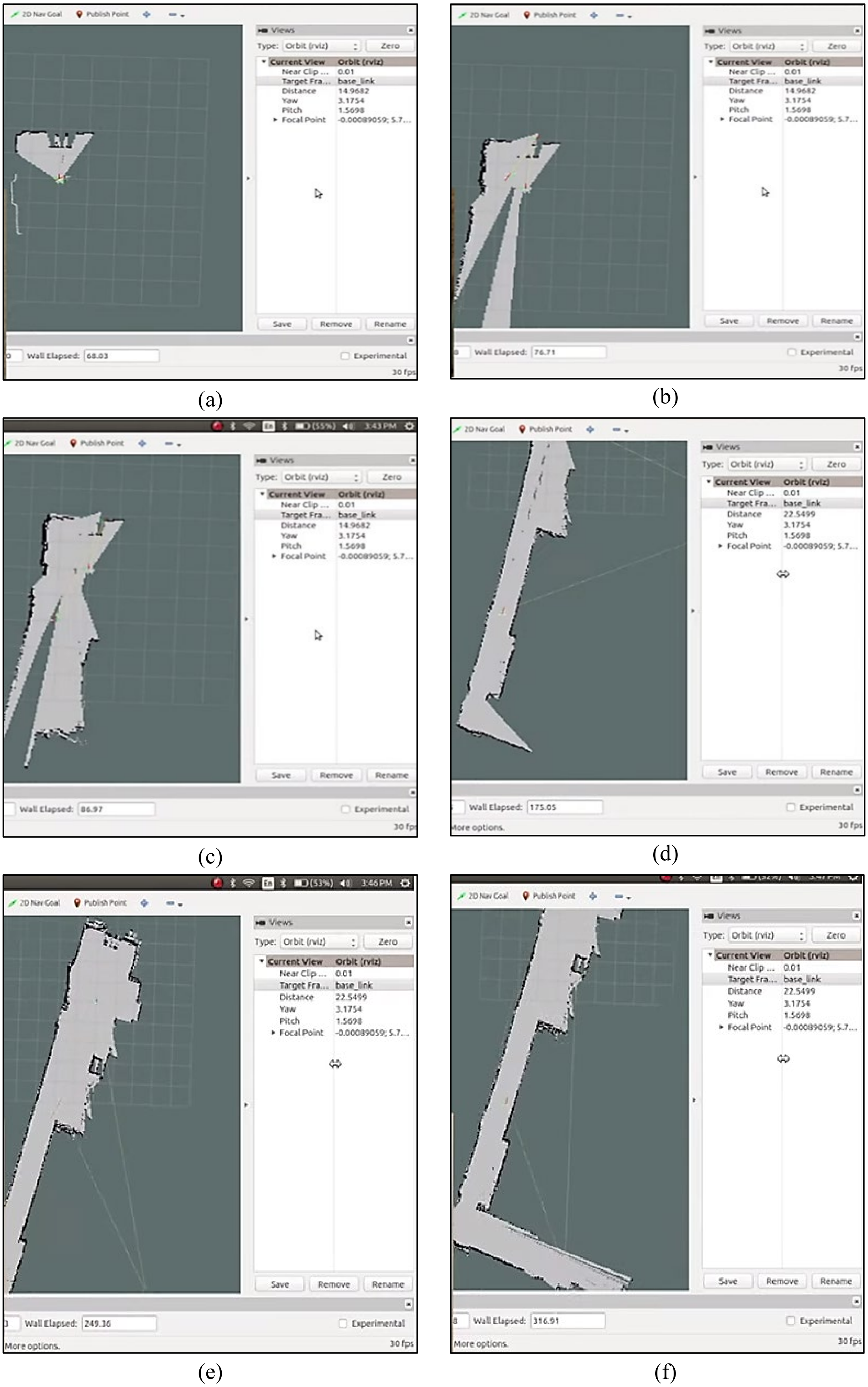
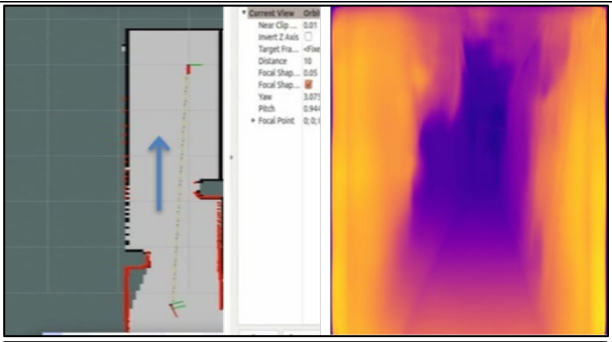
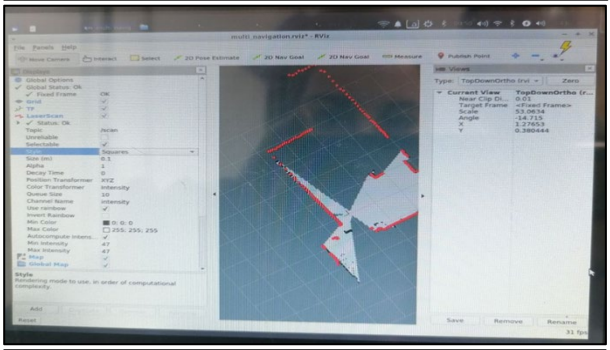
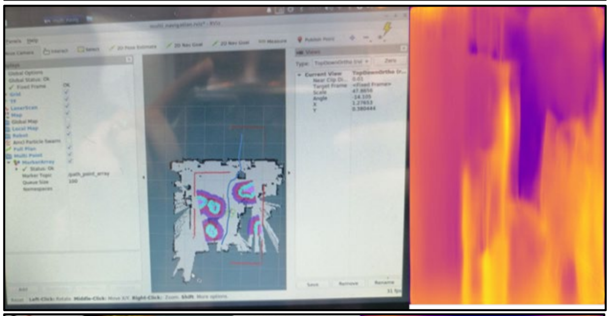
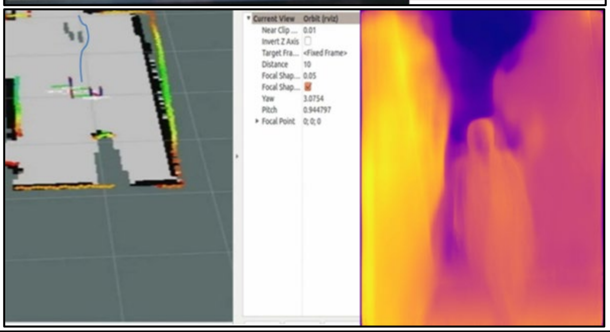


Figure 6: Robot work environment map

Table 1: Movements test results in SLAM

Tests	Results
Robot movement in the corridor The arrow shows the direction of the robot's movement.	
Robot movement within an obstruction-free room.	
Robot movement within a room with fixed obstacles	
The Robot avoids obstacles that move.	

4. Conclusions

SLAM is a computational challenge where an unknown environmental map is created or updated while simultaneously locating it. Where HectorSLAM works on construction, 2D mapping, and location. The main objective of this research is to conduct a practical experiment using the RPLIDAR A1M8-R6 laser sensor, in terms of mapping capability and automatic positioning, for the SLAM application. The sensor RPLIDAR A1M 8-R6 is located on the chassis of the mobile robot and operates in real-world situations, and uses a computational automation system (ROS). LIDAR acts as a laser sensor to scan the robot's surroundings 360 degrees and send data to the SLAM to map where the robot is working. The robot was tested in a building corridor using ROS. To give estimates of resettlement in work environments. From the results, we can note the high efficiency of the robot when avoiding obstacles due to the accuracy of the data obtained from the sensors in the proposed robot. Furthermore, the estimation results for the work environment's map in real-time are clear and more efficient for detecting the location. This robot is used in hospitals and nursing homes to deliver medication to patients.

Author contribution

All authors contributed equally to this work.

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Data availability statement

The data that support the findings of this study are available on request from the corresponding author.

Conflicts of interest

The authors declare that there is no conflict of interest.

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