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TITLE: **Simulation and Path Planning of Mobile Robots using ROS**

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Paper Authors **1Dr. G. Venkata Hari Prasad,2K. B. V. Aakarsh**

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Simulation and Path Planning of Mobile Robots using ROS

[1]Dr. G. Venkata Hari Prasad,[2]K. B. V. Aakarsh
[1] Professor, E.C.E, Anurag Engineering College.
[2] Student, Dept. of ECE, KLEF Deemed to be University.

ABSTRACT: Over decades, from defining robotics as a fictional fantasy to redefining the innovative applications of assistance and automation, it led to a revolution in the world. Robotics, being a multi-disciplinary field emerged into various domains from manufacturing to medical applications. Evolution from simple robots to human level robots describes the speed of innovation being captivated towards robotics. This paper discusses path planning techniques used by mobile robots and simulating them using Robot Operating System (R.O.S).

Key Words: Robots, Mobile Robots, Computer Vision, Deep Learning, Sensor Fusion, Path Planning, Navigation, Motion Planning, Control.

1. INTRODUCTION

Robotics is knowledge of designing, developing, and using robots in human assistance and interaction. Robotic systems consist of assistance and automation devices and systems used to process tasks under required applications. Robotics is an interdisciplinary subject that benefits from electrical, mechanical, electronic engineering, cognitive, computers, biology, and many other disciplines. Robots can be used in manufacturing, space, and underwater exploration, for repairing malfunctions automatically, or for industrial applications. Robots can be useful in any process, but they need to be programmed and controlled and let it process for automation.

LITERATURE SURVEY

❖ Mobile Robots

Mobile robots are featured with functionalities of working by integration of artificial intelligence and physical components like sensors, wheels, camera etc.

Mobile robots work on the concept of Robot Locomotion. It is described as a robot capable of traveling from one place to another.

These robots are operated without a human onboard and in contact with ground [7]. They are controlled by human operators by telecommunication where the vehicle has set of sensors to track and map the location create a path with avoiding obstacles and transfer data to human operator. They are developed for civilian and military applications to complete dangerous tasks like warfare surveillance, rescue operation, mining, and manufacturing.

These robots comprise of several components.

1.Body frame

2.Power

3.Computing

4.Actuators

5.Sensors

5.Programming and Control Unit.

❖ ROS (Robotics Operating System)

ROS is an open-source collection of several frameworks to test robots working and performing conditions in a simulated workspace. Although it is not a real time operating system it provides services like testing and planning working conditions of a robot before starting manufacturing and production [1].

It comprises and runs on several sets of operations and processes done through nodes that communicate the procedure and receive responses. The responses may include sensory data. Actuator's locations and log of completed tasks.

ROS environment is classified into three categories:

- Platform independent tools
- Client Libraries
- Code containing core application source.

Language independent main core libraries can be found integrated in the environment. Most of them are licensed under open-source licenses increasing the feasibility of users and to increase productivity of usage.

The ROS master client libraries are based on Linux/Unix based architecture more flexible to developers. ROS can be installed on Ubuntu Linux and can be used by virtual machines when performing on Windows or Mac OS. [1]

❖ RVIZ

It is a 3D visualization tool used by developers to test several applications of Robot. It gives the user or developer all the sensory data, captured images from camera sensor or map generated from mapping using a Laser sensor (LIDAR) .

It is used to simulate the 3D or 2D model simulation of a robot performing several algorithms given by the user or developer. Rviz is a highly customizable and configurable tool used to replicate the robot working environment. [1]

❖ Gazebo

It is an 3D robot workspace simulator presented as open source to create and simulate realistic environments to run robots in the world created. It has wall, floors textures and objects to replicate the real world. It can be able to simulate and test robots in simulated working conditions when linked with rviz (visualization tool). [8] This offers a high-quality rendering of the environment suitable for the robot to test its applications. The use of this simulation helps users or developers to replicate properties of buildings, houses and objects being able to perform path planning and navigation of a robot. This also comprises of sensory data like laser and camera to capture range and decide the path to initialize the process.[1]

METHODOLOGIES

The are several decision-making aspects playing a crucial role in path planning of a robot. Path planning is an aspect when a robot is given an endpoint using a marker the robot navigates using the path map generated integrated in robots and reaches the end point. [2] While in Obstacle avoidance the robot senses the surroundings from taking input from the laser and camera and modify the path according to

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the sensor in real time as it moves along the path.

These approaches are classified into two categories:

- Strategic approach (Path Planning)
- Tactical approach (Obstacle avoidance)

Path Planning is classified into several categories:

- Classic Path planning
- Sample based Path planning.
- Probabilistic Path planning

The Path planning algorithm requires several data like Environment geometry, Robot geometry, Start and Goal pose of a robot.

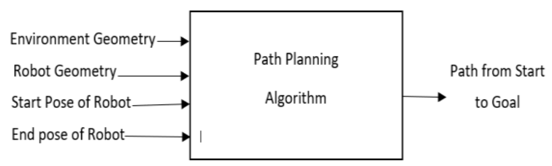

Figure 1 Flow representation of Path Planning

Evaluation of Path planning algorithms is finding the path of the robot. The methods are classified as:

- Complete method: This algorithm can find a goal from start if the path exists. [11]
- Optimal method: This algorithm can find the best path solution be able to increase accuracy of the robot path.

Approaches of Path Planning

- Discrete Path Planning:

In this algorithm approach a graph search algorithm is implemented where the robot workspace is discretized into a connected graphical representation [2]. This is a very precise process and very expensive to compute process using this algorithm. The main purpose of this algorithm is to find path planning solutions for larger capacities problems.

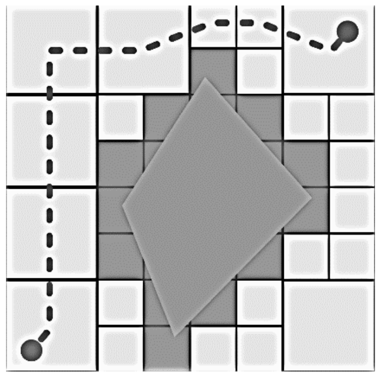

Figure 2 Discrete Path planning [3]

- Sample based Path Planning:

Different from discrete path planning, In this planning approach several no of samples are collected from the path and used them to create workspace. This is not as precise as Discrete planning approach, but it is lot quicker that it. This approach can be used from immediate results of the planning solution.

This may not be the best approach, but for certain environment applications it is a feasible and cost-efficient process to attain results.

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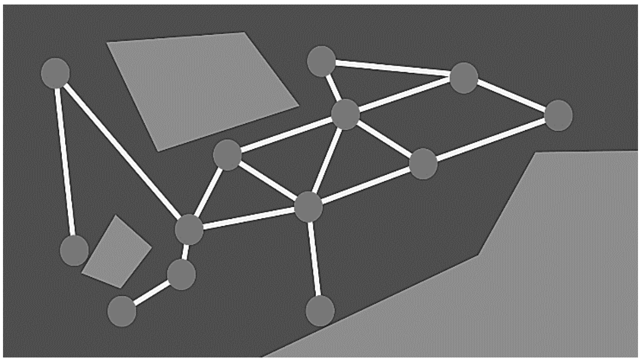

Figure 3 Sample based planning [3]

- Probabilistic Planning

In this approach the path planning is different from the above algorithm approaches. [11] This algorithm takes place in the uncertainty of a mobile robot. The map has free spaces and objects occupied in it, based on the algorithm it creates nodes and path points to create a path. The main purpose of this is to be implemented in hazardous path problems and high-risk areas.

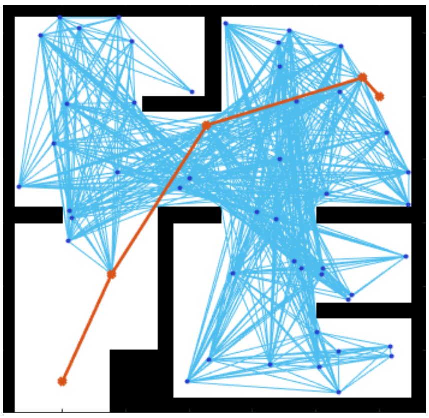

Figure 4 Probabilistic Planning [3]

IMPLEMENTATION

For the current model, the turtle bot is used for path planning. We use RVIZ to simulate turtle bot and control the motion of the robot by adding markers. This is done by integrating a simulated workspace created using Gazebo. [5]

The process requires packages installed from rviz and gazebo depositories from GIT.

❖ Turtle Bot

This is an open-source robot used to simulate and test similar mobile robot test conditions.

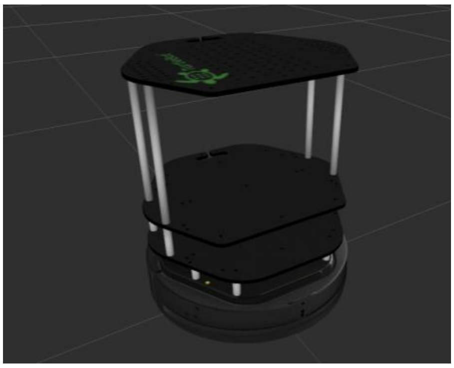

Figure 5 Turtle Bot 2 Simulated Model

We first source our environment by linking root path of ROS directory. [4] This can be neglected by adding a ~/.bashrc to auto setup source every time we launch terminal in Linux.

Required Repositories are

- Turtle bot packages
- RVIZ packages
- Gazebo Simulator
- Xterm
- Cmake and C++
- Python and PIP

Above packages can be downloaded using wiki.ros.org or GIT

Save the map created in the source location and run the .sh file from the scripts programmed.

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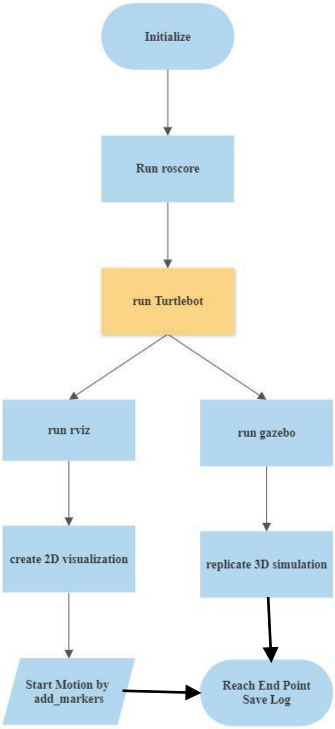

Figure 6 Executional Flow

2. RESULTS

This is the initial Map where no wall is created. The laser data projection can be seen on right image of the turtle bot.

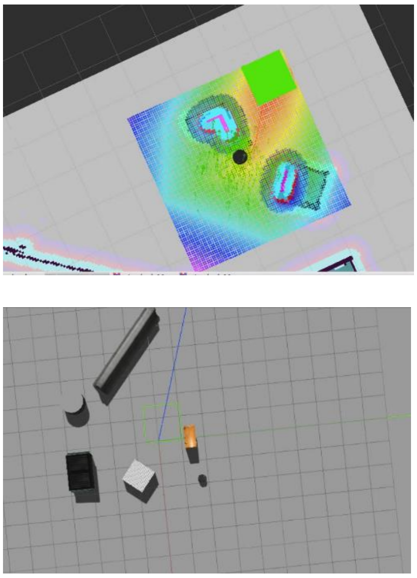

Figure 7 Initial Workspace

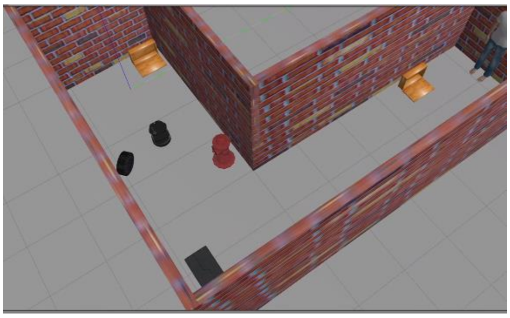

Figure 8 Map Simulation in Gazebo

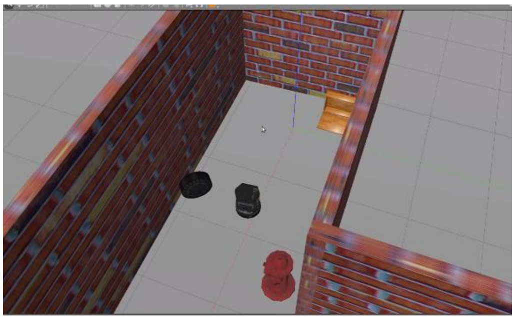

Figure 9 Obstacles in Map

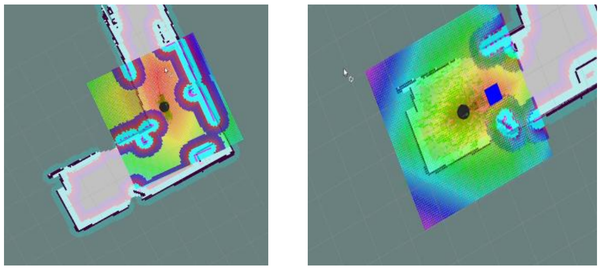

Figure 10 Wall and Path Detection

The Turtle bot moves around the given path and detects objects during its coarse set towards its goal. By adding end markers, the robot can be navigated to the end of the map and complete its goal. It senses objects and wall by LIDAR sensor simulated on it. [6] Walls are represented in dark blue color on laser representation of map.

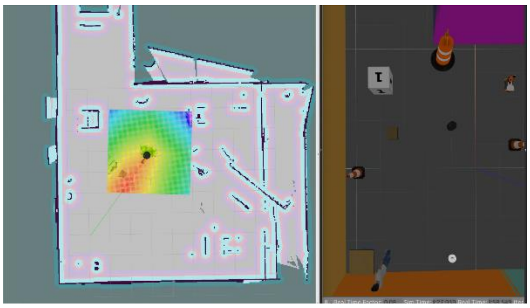

Figure 11 Larger Map/Floor

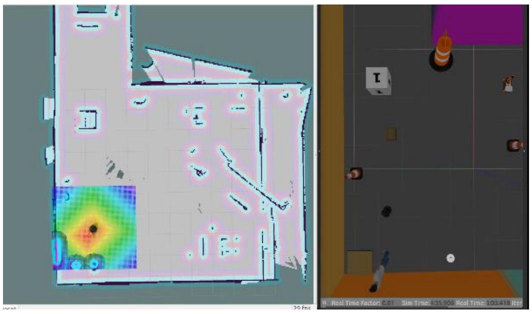

Figure 12 Goal Point Detection

When given a problem on larger scale areas, objects and wall areas are increased creating more space for the robot to commute. [9] This required a heuristic approach to cover areas if it has high risk zones.

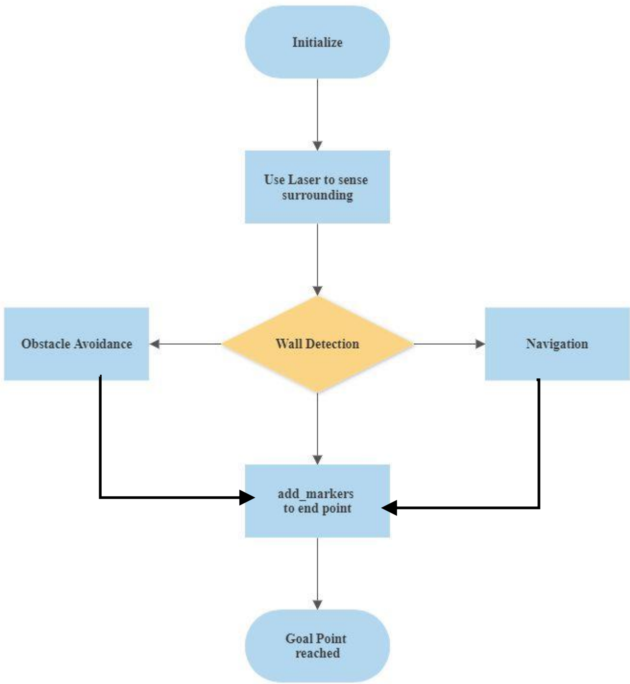

Figure 13 Path Planning Algorithm

SUMMARY

Use of Gazebo Simulator can be done in creating the world for the simulation of robot, but it has some drawbacks. Those like creating every wall block takes certain time and arrangement of those take time. We can create .png format maps and use a map generator to create .pgm and .yaml format files which can be directed used to simulate on RVIZ. This process reduces the time of creating world files and can be used to replicate our own house map making the robot get habituated to the environment

- Future Implementation

In future versions of Path planning applications, we can integrate Google Assistant SDK and give commands using "OK Google!" hot word detection. We can use an application interface to control the robot and command it to move to a location particularly given. Integration of Google voice commands help user to communicate with robot more easily. The application can be developed on Android studio for easy integration with Google services and increase fast response techniques using TTS and STT API's.

CONCLUSION

In this work, we have used ROS techniques to replicate our previous Mobile Robot implemented on Real world. As to increase its accessibility and precision it was tested on ROS framework. The future version we are working on can be implemented in real time and integrating all the features discussed on future implementation column. Meanwhile the work simulated is tested only in virtual environment it became simpler to complete the process. But testing in real world environment adds the major challenges for upcoming next model. This research was to study our robot's applications and strategies to Improve its working conditions. The problems we faced preceded to future research on the working of Mobile Robots.

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