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Optimization Of Mobile Robot In Path Planning Using SLAM Algorithm

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Abstract. In this project, The Design and Implementation of Simultaneous Localization and Mapping Robot which adopts the Robot Operating System is presented by considering both the hardware and software architecture along with the electronic communication protocols. The objective of the robot is to create a 2-dimensional map of an unexplored, unknown indoor environment, to navigate autonomously and positioning the objects. The problem is very challenging especially when Global Positioning System stop working in indoor area. To solve the problem, the indoor mapping and positioning technique is used. It combines the power of Global Positioning System and precise mapping. This technique provides the ability of real-time mapping and tracking of location information. They are several methods to achieve it which includes some traditional methods magnetic positioning, Radio wave and Radio frequency tagging. Our proposed robot model uses a Simultaneous Localization and Mapping technique for effective mapping and localization. The system composes of ideal robot car that can helps to reduce the time required to map any environment and locate the object, this is done through landmark extraction, path planning and path following algorithm. The map obtained by using this technique is given to the Path planning which process the map data and gives the optimal shortest path distance in which robot can navigate autonomously and positioning the objects.

1 Introduction

The autonomous robots are being utilized to cater human kind in several different applications ranging from everyday works to industrial level applications as their vital ability to map, localize and navigate within a given environment. In this work we developed a mobile robot communicated over Bluetooth for controlling movements of the robot, A Camera Sensing is used to map indoor environment and sensor data is sent over internet protocols in robotic operation system by establishing communication links to Matlab environment to perform simultaneous localization and mapping where probabilistic road map and path following algorithms are executed for autonomous navigation.

Mobile robots are defined to navigate in an environment and interact with it through sensor and motors. The mobile robots can be divided into two major classifications: Autonomous Mobile Robot and Autonomous Guided Vehicles.

An AMR have the potential to navigate in an unexplored, unknown environment. AMRs are able to scan the boundaries of the environment using sensors and able to design a map (model) of an environment and locate itself within this map by using a specific mapping algorithm. This feature allows the robot to construct a navigation plan and optimize a plan with a smallest path by using a path planning algorithm. An AMR can design a map for indoor environment using sensor data and locate itself in the map simultaneously at same instance of time. This feature is called Simultaneous Localization and Mapping. This sensor plays an important role in this Autonomous Mobile Robot. CAMERA is a Light Detection and Ranging sensor, which uses light in the form of a pulsed laser to detect distance at which the object located with its range. We have chosen a Camera Sensing which has a 360 degrees horizontal scanning range and maximum distance detecting up to 12 meters. CAMERA continuously scans the range within the environment that is deployed and provides a two-dimension (2D) map of the environment which includes measurement values such as Range, Distance, Angles, Cartesian Co-ordinates, and Number of the values obtained at the robot's position. Hence the robot can create a 2D map of the indoor environment by using Camera Sensing data along with SLAM algorithm

2 Literature Review

[1] SLAM is an active area of research in autonomous mobile robotics. Durrant-Whyte and Bailey provided a survey paper of The Earlier SLAM Literature

[2] Alif Ridzuan Khairuddin, Mohamad Shukor Talib and Habibollah Haron provided a review paper on the Evolution of Algorithm used for SLAM and below mentioned paper are based on recent research of SLAM robot using different sensor.

[3] This paper focuses on enhancing the way that information is received from the external environment and consequently the way that the map is determine and drawn. The better utilization of the ultrasonic sensor for detecting obstacles and walls for wheel-based robot for immediate localization was presented by Sungyoung Jung in 2006.

[4] In this paper RGB-D sensor of type RGB-BA and RGBD-BA sensor is used for simultaneous localization and mapping (SLAM). The significant dominance of these sensors is that they deliver the best source of 3D information at less prize. Unfortunately, these sensors in their present forms only have a range accuracy of up to 4 meters. This paper was presented in 2012.

[5] This paper explains an algorithm that execute an autonomous 3D construction of an indoor environment by using a single 2D Camera Sensing and its accomplishment on a mobile robot platform using the ROS. This paper was presented in 2017.

[6] This paper presents different types of sensor which are used for SLAM application. These sensors have their own merits and demerits. Although Camera Sensing has high accuracy rate, but have some disadvantage such as prize, power requirement and weight. As an alternative, it is possible to use relatively less cost sensor such the Kinect sensor which gives image and depth data to SLAM system. This paper was presented in 2018.

[7] This paper presents the planning and implementation of a mobile robot and which can be controlled autonomously for surveillance. The robot can be effortlessly merged into an existing security system that is previously present. It utilizes a 2D CAMERA sensor for mapping and HD camera for recording continues suspicious activity. This paper was presented in 2018.

3 Proposed System

Both Mechanical, Electronic components and software should be considered together in the design process. The hardware design of the robot includes both mechanical and electrical components connected together to make the robot to meets its objective.
The mechanical design procedure contains all the mechanical components of the robot system which enables the robot to move in physical environment.

We have designed a robot for a smooth surfaced indoor environment which makes use of wheels for locomotion. The robot consists of two pair of chassis, four DC motors, and four car wheels. The two rectangular chassis are placed one above the other. On the lower chassis robot controlling system is placed and on the upper chassis sensor system is placed. The motors selected are 100 rpm geared DC motors. The type of motor has been determined as per the weight of the robot and the speed which is required for the sensor resolution and data flow. This is the most predominant factor in the locomotion control of the robot system. The four motors are connected to wheels via a drivers L298N, thus this enables robot for smooth navigation.

3.1 Aim

Let’s say that a building was attacked by terrorist and the police officers or officials wants to execute an operation to catch the terrorist. For that they should know the map of the building to execute the operation of recuing people so this project aims in developing a robot which helps in generation of path planning and Object Recognition of the building and also delivers the trajectory path of the robot.

3.2 Objectives

Design and Implement of Camera sensed for movement Trajectory
Design and Implementation of Video to path planning and Object Recognition blueprint
Designing of path planning of path planning and Object Recognition blueprint

4 Methodology

In the design procedure, we assembled the electronics components on the robot body. Now the suitable programs for the defined operation of the robot have to be done by considering the objective of the robot. Fig.1. Represents the step by step procedure

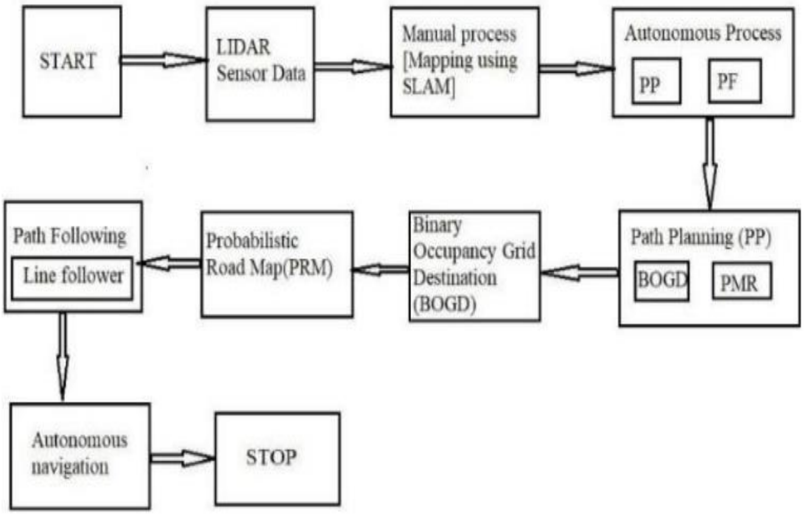


Fig. 1. Step by Step representation of software implementations

Here software implementation is majorly divided into 2 parts.

A. Manual Process: Mapping

B. Autonomous Process: Path Planning and Path Following.

A. Manual process: Mapping

Mapping is a one-time process, it is done by using SLAM algorithm.

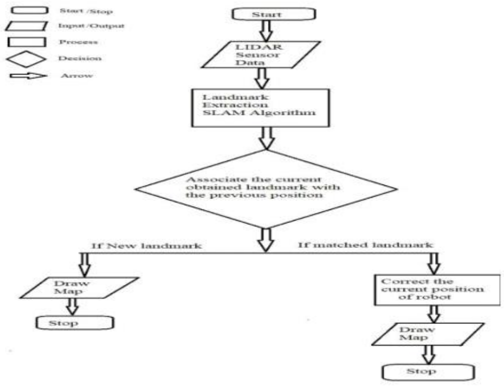


Fig. 2. Flow chart representing SLAM Algorithm

When the robot starts traveling around the indoor environment using a robot controlling system. The Camera Sensing starts rotating in a 360- degree and simultaneously sends sensor data to a Raspberry Pi through ROS network, Data from raspberry pi is sent to the laptop, were in Matlab will access the obtained data and starts landmark extraction using SLAM algorithm. This algorithm calculates the estimated value obtained from the Camera Sensing. It works in a three-step process, Predicting, Observing, and Updating using repetitive iterative process. In the first stage it associates the currently visible landmarks with those that it has observed from previous position. If the obtained landmark is new it will draw a new map, or if the obtained landmarks is matched with the position of the previous landmarks then it will correct the current position of the robot and draw/update the map again. This works iteratively. At a single position of the robot, CAMERA senses the data in 20 iterations.

4.1 Power System

A power system basically consists of battery and a power regulation system. We have used a Lead-Acid battery of 12v, 1.2Ah and power bank of 5.1v, 2A. Lead-Acid battery provides power to motors via motor driver L298N. The power bank will supply power to both Raspberry Pi and Arduino Uno Micro-controller, Through the Raspberry Pi, Camera Sensing are powered and the micro-controller in turns powers up the Bluetooth. The two batteries are placed on the lower part of the chassis**.**

4.2 Robot controlling system

Robot chassis which contains the four motors is interfaced with the micro-controller Arduino Uno using General Purpose Input and Output pins (GPIO) through L298N motor driver. Bluetooth HC-05 is connected with the Arduino Uno board using GPIO pins. This entire controlling system is placed on the lower part of the chassis; Thus the locomotion of the robot can be controlled in two ways. One is by connecting the Bluetooth HC-05 module with the laptop to control from Matlab. Matlab uses Graphical User Interface (GUI) buttons for directing th e robot movement. Another way is by installing an Android mobile App. We have used Arduino RC application through which we can control robot locomotion.

4.3 Sensor System

On the upper part of the chassis Camera Sensing and Raspberry Pi 3b+ model along with the touch screen display are placed. CAMERA A1 360-degree sensor is interfaced with Raspberry pi through the USB port. Raspberry Pi provides power supply to CAMERA by connecting to Power bank. Initially, Raspberry Pi is booted with Robot Operating System (ROS) software package. ROS is connected with the network (Raspberry pi) and by using
ROS network configuration, the environment should be set in Matlab, where Python should have a ROS package, after that publishing the Laser scans data from CAMERA to Python. Python installed in laptop configures the mapping and navigation. On both display screen and laptop output will be displayed.

5 Working principle

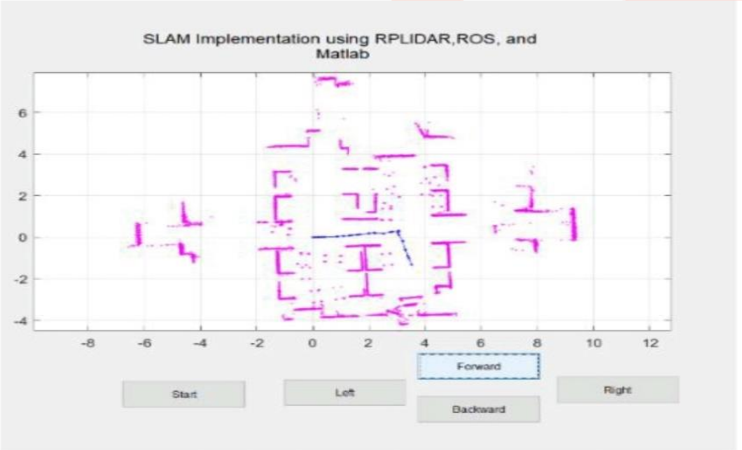


Fig. 3. The output obtained by the robot using SLAM algorithm -2D Map

5.1 Path planning

Path Planning is the second most important part of an autonomous mobile robot after obtaining a map. Path planning is defined to determine the path that a robot must travel to pass over every point in an environment. The problem of path planning is to reach a particular destination when given an initial position and orientation while avoiding all obstacles to reach the destination point. The planned path should be free of collision and satisfies optimization criteria which are calculated by the shortest path distance.
Path Planning will take place in two steps by using 2 different algorithms.

- Binary Occupancy Grid Destination (BOGD).
- Probabilistic Road Map (PRM).

5.2 Binary Occupancy Grid Destination.

Occupancy Grid belongs to a group of probabilistic robotics algorithm for autonomous mobile robot. The occupancy grid algorithm represents a map obtained from SLAM algorithm as an evenly spaced area of binary random variables. Each variable representing the present location in an environment. A binary occupancy grid uses true value to represent the space occupied by the obstacles with black color and false value to represent the free workspace where there are no obstacles with white color, then occupancy grid shows where obstacles are and whether a robot can travel through that environment or not. Occupancy grid is two- dimensional array, so at first all the 3D points will be projected onto a 2D plane which parallel to the road. Then the 2D plane is discretized into several cells with the same size. Fig.4. Shows the definition of an occupancy grid in 2D and after obtaining the occupancy grid map. Now we have to select the destination for which robot has to travel autonomously, Fig.5. Shows how to choose the destination point.

6 Probablistic Road Map(PRM)

The probabilistic road map planner is path planning algorithm, PRM builds a single road map that aims to cover an entire portion of the environment. The shortest path planning algorithm is then used to navigate across the road map. The important point to note on is PRM itself finds a path between the starting point and destination point and builds a graph (road map) for travelling through an area. Once the road map is constructed a suitable shortest algorithm Dijkstra's algorithm is used to determine an optimal path.

The probablistic road map planner occurs on two phases

- Construction Phase
- Query Phase

6.1 Construction Phase

In the construction phase, PRM generates a limited number of random nodes by approximating the motions that the robot can be made to cover a given environment. While a decent number of nodes are produced, The PRM algorithm ends placing nodes and it converts nodes into connected components. Hence a roadmap (graph) is built.

6.2 Query phase

As the road map is generated, to perform path planning. In the query phase, the simplest and best algorithm Dijkstra's [8] is used to generate the shortest distance plan between source point to a destination point by calculating the distance of each connected node between starting and destination point. Fig.4. Representing the obtained output of that planning using PRM algorithm

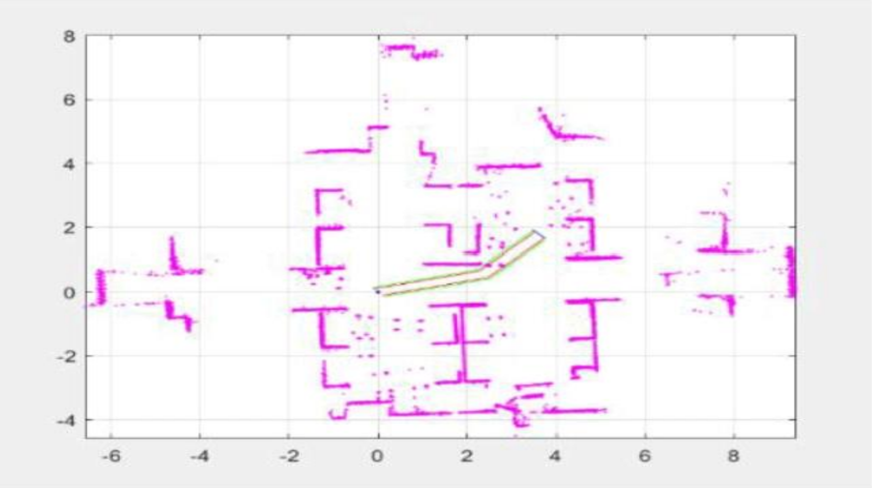
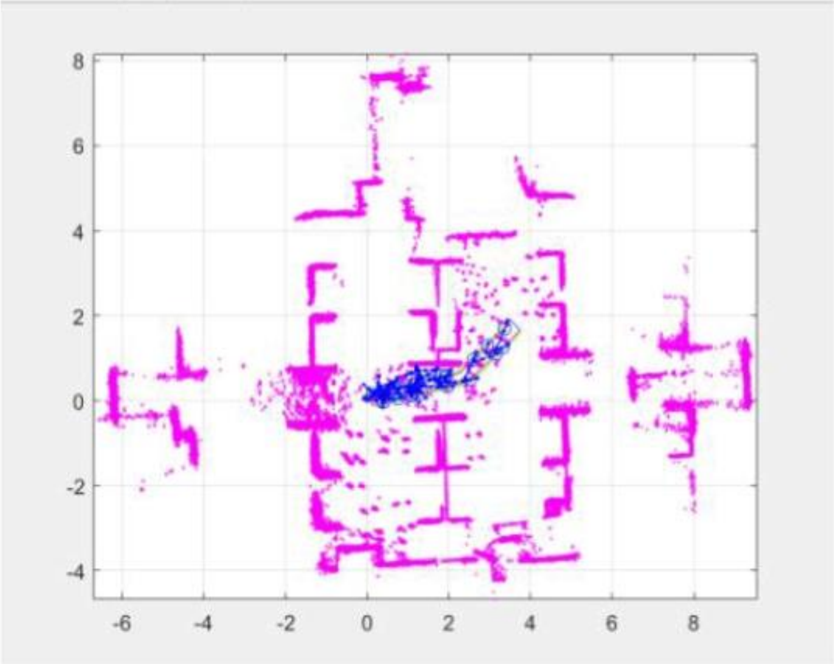


Fig. 4 Representing successful outcome of path planning using PMR

6.3 Path Following

After obtaining a path form path planning algorithm. A simple line following concept is used for the robot to navigate autonomously in the path created by PRM, Robot must be able to detect a particular path and that enables the robot to track the path drawn on the flat surface. The path can be drawn in any color, may be with visible black line on a white surface (reverse) or any other required color. Speed can be controlled according to the requirement. The speed is made limited during special situation such as passing through an edges due to the friction and torque of the tire and the floor. Fig.5. The final output obtained by path following.



. **Fig. 5. Path followed by robot navigates to reach destination**

7 Conclusion

Real-time and accurate chassis navigation is a core function to enable substation robots to complete inspection tasks. The autonomous navigation system is a key technology of robot intelligence.This study focused on the research and implementation of the autonomous navigation system of an auxiliary operation robot in an indoor substation environment.The autonomous navigation system has three parts: multi-sensor data fusion positioning and mapping, robot navigation path planning, and automatic stopping and obscle avoidance. e experimental analysis was conducted on the complete autonomous navigation system. The results indicate that the developed system contains the indicators and demands of the distribution switchgear auxiliary operation robot project, and the practical value of the system was verified.

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