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Autonomous Robot Navigation in Known Environment

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Abstract: ***Autonomous robot navigation is one of the challenging researched topic in robotics. A secure and optimal path in known environment is required for any mobile robot navigation for navigation purpose. In this work, a Simulink model is proposed based on Pure Pursuit and path following controllers for solving the problem of mobile robot navigation in a known environment is presented. Pure Pursuit controller is used to find the linear and angular velocities of the robot. Moreover, (x, y) coordinate position of robot and waypoints are input to the pure pursuit block. Velocity commands are sent to drive robot on the given path. The main aim of the proposed model is to find the obstacle free path for the mobile robot navigation. However, the robot is to navigate from start to target location without hitting obstacles. For experimental results, Turtle Bot Gazebo simulator is used. "Robotic system Toolbox" of the MATLAB is used to program the navigation process.***

Keywords: Autonomous, Localization Motion Control, Navigation, Path Planning and Search Algorithms.

I. INTRODUCTION

Nowadays, robot plays vital role in our society. This is because humans are being replaced by robots from very basic to dangerous activities. Navigation is one of the most interesting researched topics in autonomous robotics. Navigation of robots is a common problem in these applications. Mainly, localization and path planning must be included in the robot navigation. Grid map based navigation is widely known as one of the effective ways [1] [2]. The grid maps are generally built by using SLAM and PRM algorithms. However, creating occupancy grid maps in a real world is too difficult task. Occupancy grid map based navigation can provide precise localization and path planning. However, grid map based navigation has various problems. Creating precise grid maps of wide environments is time consuming. Furthermore, velocity commands are not directly sent to the robot. The navigation task is completed through grid map and it is less time efficient. A robot system that does not depend on such precise grid maps is desired. This study aims to propose a navigation system without grid maps. Furthermore, if obstacles are present in the path, there is chance that Robot get collide with the obstacles.

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The aim of navigation is to find the secure and optimal path for mobile robot. Navigation process is mainly based on following steps: To create the map of the environment, save that map in corridor world, identify the feasible path from start to target in the given map and finally to drive the robot on that feasible path. To drive robot on given path without colliding with obstacles in static environment is difficult task. In [3], a bio-inspired algorithm based on differential evolution is presented. The job is to check the next free position on each iteration and minimize objective function based on Euclidean distances. Petri nets are used for obstacle avoidance as presented in [4]. The supervised system is used for obstacle avoidance in known environment. Path planning is an important parameter to find best optimal path between source and destination. Optimal path may be defined as the path which minimizes translation and rotation. Currently path planning is most researched topic in mobile robot navigation [5]. To solve the problem of path planning an algorithm based on free segments and turning points in known environment was presented in [6]. The aim of this algorithm is to find the feasible path between source and goal. It also reduces path length without colliding with obstacles. An evolutionary algorithm is used for robot navigation which make use of sensors and motors to control robot as stated in [7]. Navigation based on odometery and global positioning is presented [8]. Wireless sensors are used for navigation in collision free path. In [9] various algorithms based on path planning techniques are compared and verified. After analysis JPS algorithm is used to find the shortest path quickly in static environment only. Moreover, where there is no real time analysis and only objective is to find shortest path then, Basic theta* is recommended. HCTNav algorithm for robot navigation is cost effective technique for indoor environment. It also shows better results than Dkjistra's algorithm as stated in [10]. A heuristic approach and map building are presented in [11].

II. PRELAM INARY WORK

A. Environment Setup

To setup environment, we first of all bring up a robot in the environment. Then, we take a Simulated Turtlebot in the Corridor world of the Gazebo Simulator. The command need to be executed on Ubuntu terminal as presented below. As an output, the corridor world of gazebo simulator with simulated Turtlebot opens and presented as follows Fig 1.

Command To bring up 'Corridor World' Roslaunch turtlebot_gazebo turtlebot_world.launch (File name)

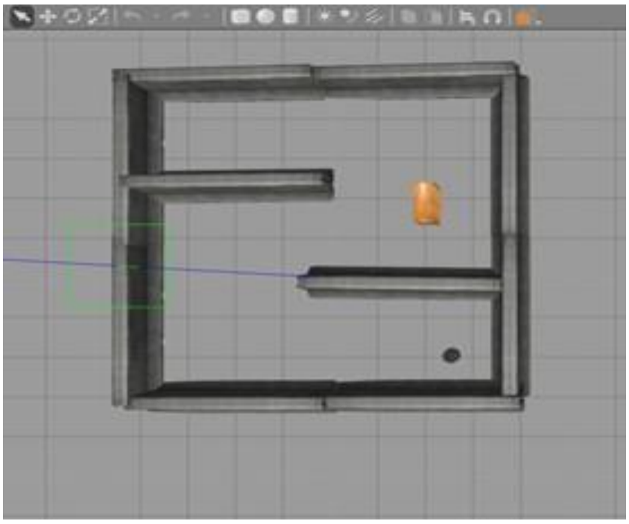

Fig. 1. Command To bring up 'Corridor World'

B. Optimal Waypoints Extraction

Once the desired Corridor World of Gazebo Simulator is created. Also, there is need to capture (x, y) coordinates of the environment by moving Turtlebot using Keyboard Tele- operator command. Now, we have to extract optimal waypoints by moving the turtlebot using the Keyboard tele-operator command presented. By executing the following keyboard-Teleoperator command:
Roslaunch turtlebot_teleop keyboard_teleop.launch
operator command we perform operation on robot to move in corridor world. For waypoints extraction a MATLAB code is executed to write down desired (x, y) coordinate position of robot in a text file. The data stored in text file is used to provide waypoints of the desired path which robot can follow while moving from source to goal. Waypoints used in this model start position (-0.0000 -0.0000) and goal position (3.9341 5.0792).

III. ALGORITHM FOR PROPOSED WORK

The following steps are to be followed by robot for path planning and navigation from start to goal location.

1) Determine the current position of the robot in the actual environment.
2) compute the linear and angular velocities of the robot.
3) Send these velocities command to the robot.
4) Check whether robot is close to goal stop, if no then,
5) Repeat the process until robot reaches the goal location.

IV. PROPOSED WORK

A. Proposed Simulink model

The Fig. 2 shows Proposed Simulink model. The proposed model implements the path following controller based on pure pursuit algorithm. The controller receives the robot pose and scans data from the simulated robot and sends the velocity commands to drive robot on given path.

The subscriber receives messages sent on the "/Odom" topic. The odometry data of robot is sent on topic "/Odom". The (x, y) location of robot is then extracted from Msg of "/Odom". New Msg is sent to collect new sensor information. Quat2Eul is a Matlab function, which converts the Quaternion function to Euler angle. Yaw orientation of the robot is then extracted from the pose message. The path is specified as a set of waypoints that the robot follows. Waypoints are considered as two-dimensional coordinate position of the robot. In the given environment, waypoints are considered at different points. Among different points, one is starting position of the robot. The second one waypoint is goal or target location of the robot. The other one is near to the obstacles so as to identify whether robot avoid the obstacle or not. Pure Pursuit receives two inputs one is (x, y) position of the robot and set of waypoints. Pure Pursuit block computes the linear and angular velocities of the robot. Moreover, without taking obstacles into consideration the robot can navigate from source to goal location. Path following controller used in this model to follow the waypoints, so that robot can navigates in the given environment by avoiding obstacles present in the path. To stop the robot once it reaches at goal location. The goal is the last waypoint on the path. This Pure pursuit also compares the current robot position and the goal point to determine, if the robot is close to the goal. The 'Outputs' subsystem publishes the linear and angular velocities to drive the simulated robot. It adds the velocities computed using the Pure Pursuit algorithm. The final velocities are set on the "Odom" message and published on the topic. This is an enabled subsystem which is triggered, when new laser message is received. This means a velocity command is published only when a new sensor information is available. This prevents the robot from hitting the obstacles in case of delay in receiving sensor information. Scope is used to plot angular and linear velocities of robot with respect to time.

B. Path Pursuit

Once the feasible path from start location to target location in the given environment is determined, the robot just follows the waypoints to reach the target location. Path following controller based on pure pursuit algorithm are used to follow to find the feasible path.

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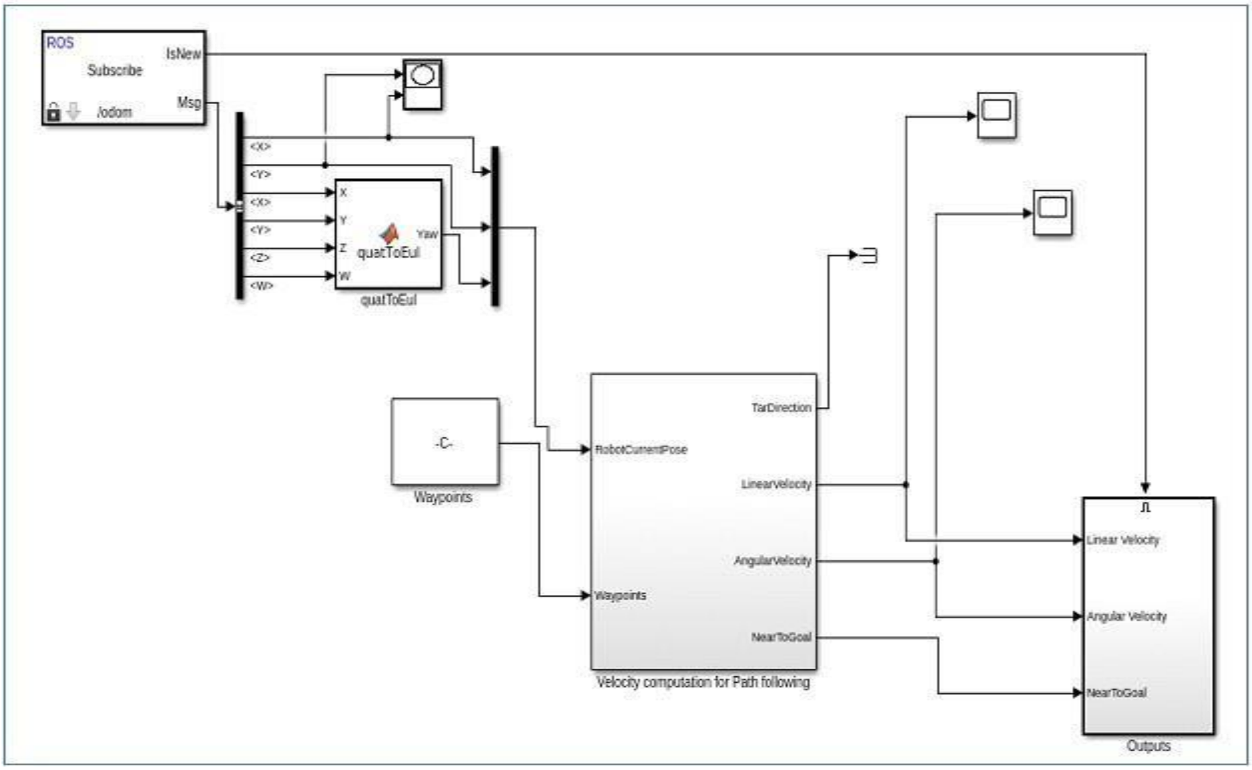

Fig. 2. Proposed Simulink Model

V. RESULTS AND DISCUSSION

In Fig1. Shows corridor world when the robot is at start location. On executing the proposed Simulink model, the robot navigates successfully by following the set of waypoints and reaches at the goal. In Fig 3. Shows that robot is at goal location. The robot navigates successfully by avoiding obstacles present in the path. The path followed by robot is being plotted and as presented in Fig 4. The linear and angular velocities with respect to time are also plotted as presented in Fig 5. and Fig 6. Respectively. These velocities are used by robot to follow the waypoints to reach destination. The angular velocity is get changes at each interval of time. Moreover, linear velocity also shows minor fluctuation with respect to time but remain constant throughout the navigation process.

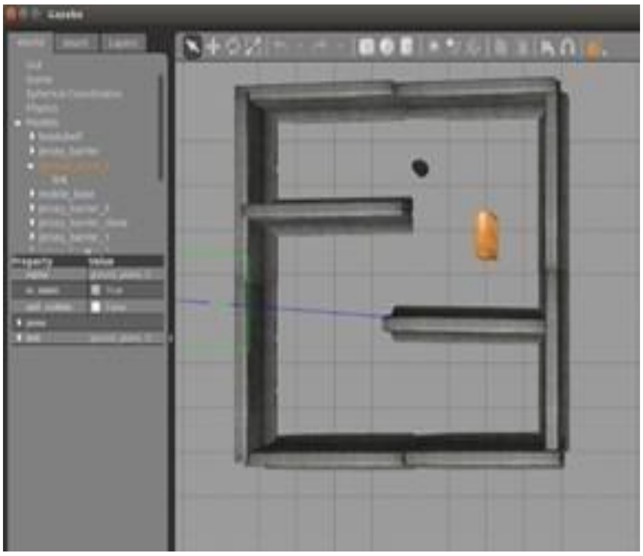

Fig. 3. 'Corridor World' when robot is at goal location

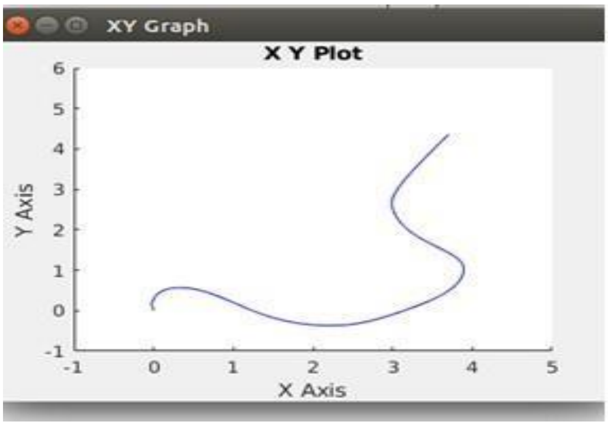

Fig. 4. Path plot followed by Robot from source to goal

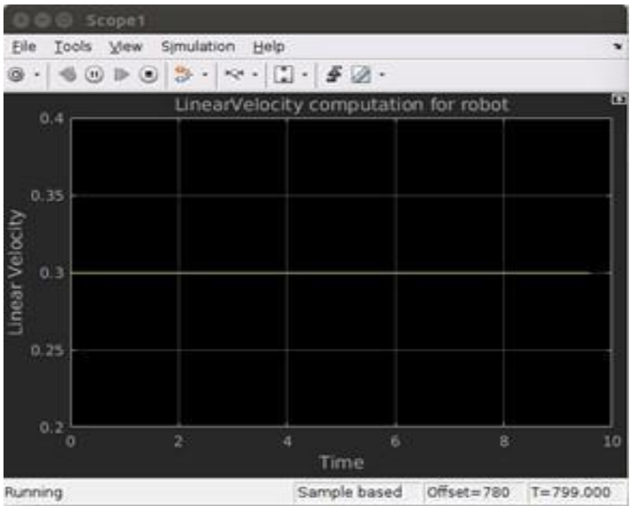

Fig. 5. Linear Velocity computation for Robot

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VI. EXPERIMENTAL SET-UP

The experimental work is carried out on a computer with dual-core 2.4 GHz + Intel i7 Processor and 4 GB of RAM. The operating system used here is Ubuntu 16.04 LTS. The version of Robot Operating System (ROS) is Kinetic (1.12.2). Turtlebot-Gazebo simulator 7.0.0 is considered for the imple- mentation of the proposed model. MATLAB R2018 is used for programming purpose. ”Robotic system Toolbox” of the MATLAB is used to program the navigation process.

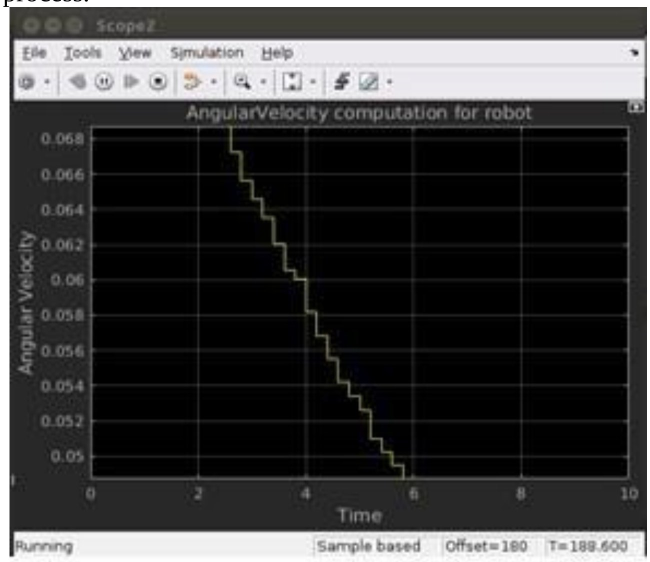

Fig. 6. Angular Velocity computation for Robot

VII. CONCLUSION AND FUTURE SCOPE

The proposed model has ability to avoid the obstacles present in the path. This model works in known environment and follows the waypoints. Moreover, Robot navigate from source to goal successfully and avoids the obstacles present in the path, regardless of their shape and size. On comparing with grid map based technique the proposed method is time efficient. In Known environment map of the environment is predefined. This model work in the known environment, where prior information is available. In future, we extended this work for dynamic environment. Where, there is less or no prior information is available. Simulation results are performed on Turtle-bot Gazebo to demonstrate that proposed method is good alternative to solve robot navigation problem in known environment.

DECLARATION

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Availability of Data and Material/ Data Access Statement	Not relevant.
Authors Contributions	All authors having equal contribution for this article.

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