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Simultaneous Localization and Autonomous Environment-Mapping Robot

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Abstract* — Robots have been gaining popularity due to the fact that they tend to deliver tasks at much more greater pace and lesser energy usage. Over the last decade it has beenwidely helping human labours in factories to carrying out tasks, it is used to carry out basic home tasks, and are also used in medical fields like carrying out surguries.The problem of generating maps with mobile robots has received considerable attention over the past years. In this proposed project the problem of creating maps with mobile robots in dynamic environments are considered. The robot will perform mapping process based on two operating modes, Scanning and Mapping and Navigation. The scanning process will be done in two steps namely 180^0 Scanning and Matrix Generation and Navigation will be done in two steps, Direction algorithm and (x,y) algorithm. Robotic mapping deals with the study and application of ability to construct map or floor plan by the autonomous robot and to localize itself in it. Autonomous Robot is an intelligent robot because it will itself locate the area which has to be mapped and navigate itself as per predefined algorithm.

Index Terms **— Scanning and mapping, navigation, autonomous robot, localization.**

I. INTRODUCTION

Robots are becoming more and more common in our daily lives showing up in the form of everything from children’s toys, to robotic vacuum cleaners, to home security robots; robots have been doing automated tasks in factories for decades. With the ever-increasing speed and power of digital systems coupled with the continuously expanding field of robotics, it is becoming more practical to build custom robotic systems with a degree of flexibility and freedom that was once impossible, giving robots the ability to communicate wirelessly or to act autonomously.

Autonomous Mobile Robots are robots that can perform a desired task in an unstructured and unknown environment without continuous human intervention. Autonomous Mobile Robot can gain information from the environment, it can work for an extended period without human intervention, it moves either all or part of itself throughout its operating environment and it avoids situation that are harmful to people, property or itself unless those are part of its design specifications.

SLAM is a technique used by robots and autonomous vehicles to build up a map within an unknown environment (without a priori knowledge) or to update a map within a known environment (with a priori knowledge from a given map) while at the same time keeping track of their current location.

Mapping is the problem of integrating the information gathered by a set of sensors into a consistent model and depicting that information as a given representation. It can be described by the first characteristic question, “What does the world look like?” Central aspects in mapping are the representation of the environment and the interpretation of sensor data.

In contrast to this, localization is the problem of estimating the place (and pose) of the robot relative to a map. In other words, the robot has to answer the second characteristic question, “Where am I?” Typically, solutions comprise tracking, where the initial place of the robot are known, and global localization, in which no or just some a prior knowledge about the ambiance of the starting position is given.

SLAM is therefore defined as the problem of building a model leading to a new map or repetitively improving an existing map while at the same time, localizing the robot within that map.

SLAM is one of the major challenges. If a robot is placed into a completely novel environment, robot should be able to explore that environment in an intelligent manner. However, a robot in this situation has no idea of the

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environment it has just been placed in and as such does not have a map. It must create a map as it moves around. This is where it gets difficult. In order to create a map of an environment, the robot must know where within the environment it is currently located. Robot needs to know where it is in order to create its map. It needs to be localized within its environment. This is very much the chicken and the egg problem - to localize a robot needs a map, and to map the environment the robot needs to be localized. In a novel environment the robot starts with no map and has no idea where it is. As it starts moving it simultaneously creates a map and use that dynamically changing map to try and work out where it is- it must SLAM.

II. PROBLEM DEFINITION

The main aim of an autonomous robot is to be able to construct (or use) a map or floor plan and to localize itself in it. Robotic mapping is that branch which deals with the study and application of ability to construct map or floor plan by the autonomous robot and to localize itself in it. It is an intelligent robot because it will itself locate the area which has to be mapped and navigate itself as per predefined algorithm. Initially, the robot will start mapping process from any corner of an arena prescribed by the use. The start point of the robot will be designated as block position (0, 0) where robot will start its operation. Initially, the robot will be facing NORTH. At block position (0, 0), the servomotor shaft will rotate in a semi-circular orientation from 0^0 to 180^0. The sensor mounted on a shaft of a servo motor will take different samples at different angles. These samples in a form of range will be sent to the computer. Thus, the robot will navigate, scan and map the arena as per the predefined algorithm.

III. REQUIREMENTS

Hardware Requirements

(a) Firebird V(Atmega2560): Required for mapping.
(b) ZigBee(XB24): Serial communication from bot to host pc.
(c) Servo motor (VS1): Scanning with resolution of 9^0.
(d) Sharp IR Sensor (GP2D12): Measuring distance between bot and obstacles.

Software Requirements

(a) AVR studio: To program instruction onto a given bot.
(b) MATLAB: Displaying the integrated map.

IV.REVIEW OF RELATED WORK

1. Dirk Hanel et.al [2] has considered the problem of creating maps with mobile robots in populated environments. This approach uses a probabilistic method to track multiple people and to incorporate the results of the tracking technique into the mapping process. The resulting maps are more accurate as corrupted readings are treated accordingly during the matching phase and the number of spurious objects in the resulting maps is reduced. This approach has been implemented and tested on real robot systems in indoor and outdoor scenarios. Several experiments illustrating the capabilities of the approach to generate accurate 2d and 3d maps is presented.

2. John J. Leonard et.al (1991) [4] has discussed about a significant open problem in mobile robotics: simultaneous map building and localization. The ultrasonic sensing is used and to overcome the issue of "The map or the motion?" the vehicle is equipped with multiple servo-mounted sonar sensors, to provide a means in which a subset of environment features can be precisely learned from the robot's initial location and subsequently tracked to provide precise positioning.

3. Wolfram Burgard et.al [3] has considered the problem of creating maps with mobile robots in dynamic environments. A new approach that robot because it will itself locate the area which has to be mapped and navigate itself as per predefined algorithm. Interleaves mapping and localization with a probabilistic technique to identify spurious measurements is presented. In several experiments we demonstrate that the algorithm generates accurate 2d and 3d in different kinds of dynamic indoor and outdoor environments. The algorithm is also used to isolate the dynamic objects and to generate three-dimensional representation of them.

4. M. W. M. Gamini Dissanayake et.al [6] proves that a solution to the SLAM problem is possible. The underlying structure of the SLAM problem is first elucidated. A proof that the estimated map converges monotonically to a relative map with zero uncertainty is then developed. It is then shown that the absolute accuracy of the map and the

vehicle location reach a lower bound defined only by the initial vehicle uncertainty. Together, these results show that it is possible for an autonomous vehicle to start in an unknown location in an unknown environment and, using relative observations only, incrementally build a perfect map of the world and to compute simultaneously a bounded estimate of vehicle location. It also describes a substantial implementation of the SLAM algorithm on a vehicle operating in an outdoor environment using millimetre-wave (MMW) radar to provide relative map observations. The implementation is used to demonstrate how issues such as map management and data association can be handled in a practical environment. The results obtained are cross-compared with absolute locations of the map landmarks obtained by surveying. Issues raised by the solution to the SLAM problem including suboptimal map-building algorithms and map management are discussed.

5. Prathamesh Akolkar et.al [1] has constructed an Autonomous Mapping Robot that is an efficient product for mapping a particular room or area by localizing itself in an area. It detects the obstacles and navigates itself in an area by avoiding the obstacles. Mapping is done without human efforts which are plotted on matlab accurately. The data transmitted by robot will be sent to host PC via zigbee wireless module to give real time map of an arena.

6. Jonathan Hayden et.al [5] has designed and built a prototype of an autonomous mapping robot capable of producing a floor plan of the interior of a building. Several technologies were combined including, a laser rangefinder, ultrasonic sensors, optical encoders, an inertial sensor, and wireless networking to make a small, self-contained autonomous robot controlled by an ARM9 processor running embedded Linux.

V. SOLUTION STRATEGY

The robot will perform mapping process based on two operating modes.

1. Scanning and Mapping.
2. Navigation.

- The robot will start its operation from any one corner of an arena. At this point, the robot will have (0, 0) block position.
- Next, the robot will be facing towards 'NORTH' direction as per predefined algorithm by initializing its (x, y) as zero i.e. x=0 and y=0.
- The (x, y) block position will be transmitted to the host PC via wireless module.
- **Scanning**
  1. 180^0 Scanning.
  2. Matrix Generation.
- **180^0 Scanning:**

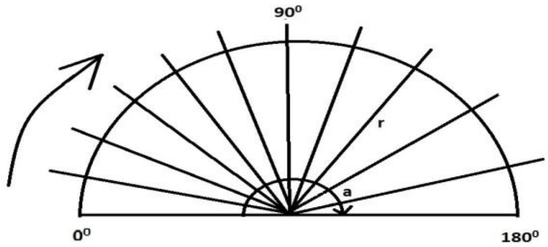

Fig 1 (a): Schematic diagram of 180^0 scanning.[1]

- The sharp IR sensor mounted on servomotor shaft will capture 22 different samples in the form of range (r) at different angles from 0^0 to 180^0.
- The servomotor shaft will rotate in the interval of 9^0 such as 0, 9,18,27,36 and so on.
- The parameters (x,y,a,r) will be transmitted for first block to the host PC.
  where,
  r=distance of the ultrasonic sensor from the obstacles in cm.
  a=angular position of servo motor shaft in degrees.
- Then, the robot will take 3 samples at 0^0, 90^0 and 180^0 to determine the number of blocks in left, forward and right direction.
- Depending upon these samples the robot will assign '0' to obstacle/wall and '1' to free space block.

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- **Navigation:**
  - Direction algorithm
  - (x,y)algorithm
- **Direction algorithm:**

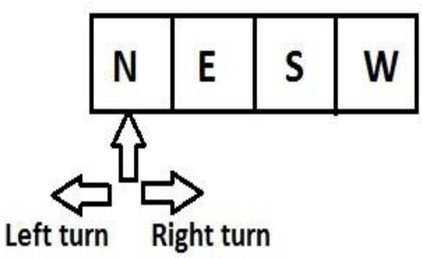

Fig 1 (b): Direction pointer [1]

- The pointer will be initially pointing towards north at the start of the map. Whenever robot turns the direction, the pointer will be incremented or decremented by 'one' depending upon the direction it is facing. For every right turn, the pointer will incremented by 'one' and will move in east direction. Accordingly the robot will upgrade its current direction which will be simultaneously sent to the host PC for display.
- **(x,y) algorithm:**

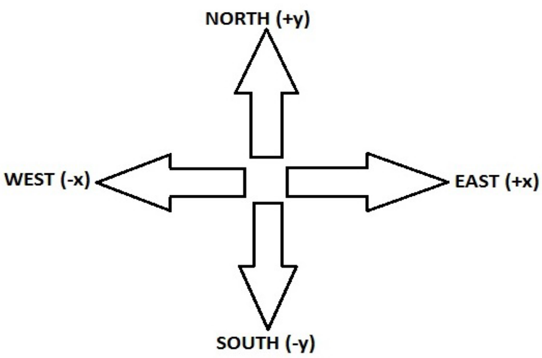

Fig 1 (c): (x, y) Algorithm [1]

- Depending upon direction, the robot will calculate its current block position(x,y) value as shown in diagram.
- Whenever the robot will move in the east direction, it will increment its x co-ordinate value.
- Whenever the robot will move in the west direction, it will decrement its x co-ordinate value.
- Whenever the robot will move in the north direction, it will increment its y co-ordinate value.
- Whenever the robot will move in the south direction it will decrement its y co-ordinate value.

VI.CONCLUSION

An Autonomous Mapping Robot is an efficient product for mapping a particular environment or area by localizing itself in an area. It also detects the obstacles and navigates itself in an area by avoiding the obstacles. Therefore, mapping is done without human efforts which are plotted on matlab accurately. The data transmitted by robot will be sent to host PC to give real time map of an arena.

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