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Autonomous Room Mapping Vehicle

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***Abstract* - With the world moving to an automated platform, robots are finding application in almost all domains to reduce the human effort. One such domain is to find a path in an unknown environment. The objective of this paper is to develop a room mapping robot that is able to map its surrounding environment. This allows the user to map areas that are not suitable for humans to traverse in. The developed model will be integrated with a computer using Bluetooth modules which enables the data exchange between the computer and the robot. The data gathering or scanning of the environment is done using a Sharp IR sensor. The sensor will be mounted on a servo motor to control the speed and direction of the scanning. The data obtained is transmitted to the computer where the data received will be further processed to obtain a map of the scanned environment.**

Keywords - Arduino, SharpIR, Room Mapping, Map Generation

I. INTRODUCTION

The use of robots in our daily lives is growing exponentially, for instance, they are utilized in the form of robotic vacuum cleaners or home security robots and even in children's toys. Also, 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 farfetched, giving robots the ability to communicate wirelessly or to act autonomously. Robotic mapping is a discipline related to cartography, which deals with the study and application of the ability of an autonomous robot to construct a map or plan by the and to localize itself in it.

The map developed is a representation of the aspects of interest (e.g., position of landmarks, obstacles) describing the environment in which the robot operates. The need to use a map of the environment is twofold. First, the map is often required to support other tasks; for instance, a map can inform path planning or provide an intuitive visualization for a human operator. Second, the map allows limiting the error committed in estimating the state of the robot.

In this study, an intelligent robot is designed, which maps the given area and navigates itself through the area being mapped as per a predefined algorithm.

The remainder of the paper is organized as follows Section II, discusses the design of the model. The working of the model is presented in Section III. A preliminary set of results of the prototype of this model are presented in Section IV. The paper is concluded in Section V.

II. DESIGN

For the purpose of this study, a model is developed using an Arduino Uno as a central unit which controls the working of the remaining components. The design of this model is as shown in Fig. 1. The sharp IR sensors are used to detect the distances of the obstacles and walls of the given area from the vehicle. The maximum range of these sensors to obtain an accurate reading is 80cm.Therefore, any values obtained which are greater than 80cm are treated as noise. This sensor is mounted on a servo motor which is used to rotate the sensor over an angle of 180 degrees. It is vital to provide appropriate delays for the servo motor movement, so that accurate values of the distance can be acquired. For instance, if the delay is very less, the sensor will not have sufficient time to obtain the value at that angle of rotation, i.e., the obtained value might be that of the next angle or the previous one. A pair of Battery-operated motors(BOmotors) are used for the movement of the vehicle. BO motors are used instead of regular DC motors, as BO motors consist mechanical gears to alter the speed/torque of the motor for an application. The Arduino operates at relatively low voltages and require a small amount of current to operate, while the motors require a relatively higher voltages and current. Therefore, the current cannot be supplied to the motors directly from the Arduino. Therefore, the BO motors are connected to the Arduino using a L293D driver IC[1]. Also, a pair of HC-05 modules are used to exchange data between the vehicle and the local computer. A pair of Arduino Uno microcontrollers are used to control the operation of the components interface with it, where one Arduino is mounted on the vehicle and the other is connected to the computer as shown in Fig. 1. The data received by the computer, i.e., obtained distance values are stored in an excel sheet, which is later provided as the input to the MATLAB program for map generation.

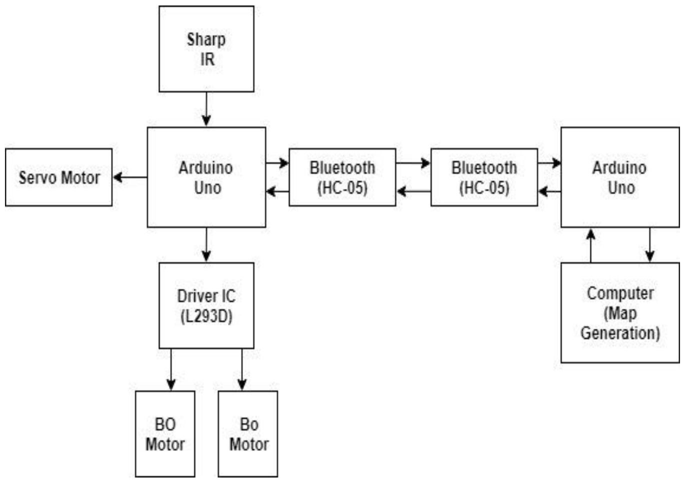

Fig. 1. Design of the Model

III. WORKING

A. Room Mapping

When the vehicle is powered on and receives a start command from the computer, the servo motor on which the sharp IR is mounted rotates from 0 to 180 degrees in 21 steps, where each step is at an angle of 8 degrees from the pervious. The 8 degree deviation in each step allows a more accurate distance value to be recorded, which in turn allows a more accurate mapping of the surroundings. The sharp IR scans the surroundings at each of these angular deviations in the servo motor. Since the sharp IR works on the principle of triangulation for distance measurement, i.e., the narrow beam emitted from the sensor after reflecting from the object will be directed through the second lens on a position-sensible photo detector (PSD) [2]. The conductivity of this PSD depends on the position where the beam falls. The conductivity is converted to voltage and the voltage is digitalized by using the analogue-digital converter in the Arduino, as shown in Fig. 2.

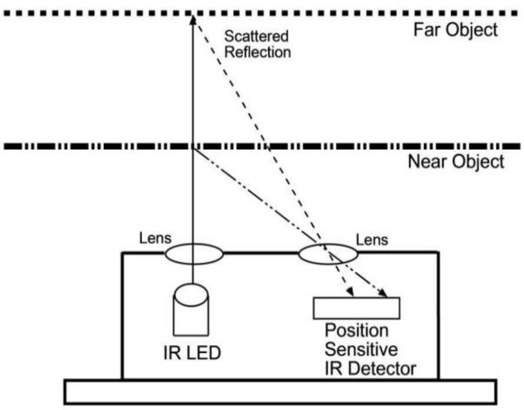

Fig. 2. Working principle of a Sharp IR sensor

Therefore, these voltage values have to be converted into centimeters (cm), so that they can be mapped. This conversion is done using (1).

$$Distance(cm) = \left(\frac{3027.4}{Sensor\ Value}\right)^{1.2134} \quad (1)$$

The distance values obtained after the conversion are transmitted to the computer via the Bluetooth module and are displayed on the Serial Monitor of the Arduino IDE [3]. The received values are also stored in an excel sheet which is provided as an input for the MATLAB code during map generation [4]. A second scan of 0 degrees, 90 degrees and 180 degrees is done to decide the direction of vehicle movement based on obstacle proximity. Once the second scan is performed, the code checks for these three conditions:

1. Left path is free.
2. The left and forward paths are blocked, right path is free.
3. Left path is blocked, forward path is free.

If condition 1 is satisfied then the vehicle turns left irrespective of the other two conditions. If condition 2 is satisfied then the vehicle turns right. When condition 3 is satisfied the vehicle moves forward irrespective of the right side path being free or blocked. Failure to satisfy the above three conditions implies the vehicle is blocked in a corner hence, it makes a 180 degree right turn (Reverse direction). This process of scanning is continued till the area is mapped. Fig. 3 shows a flowchart of the steps involved in the mapping process working of the model mentioned above.

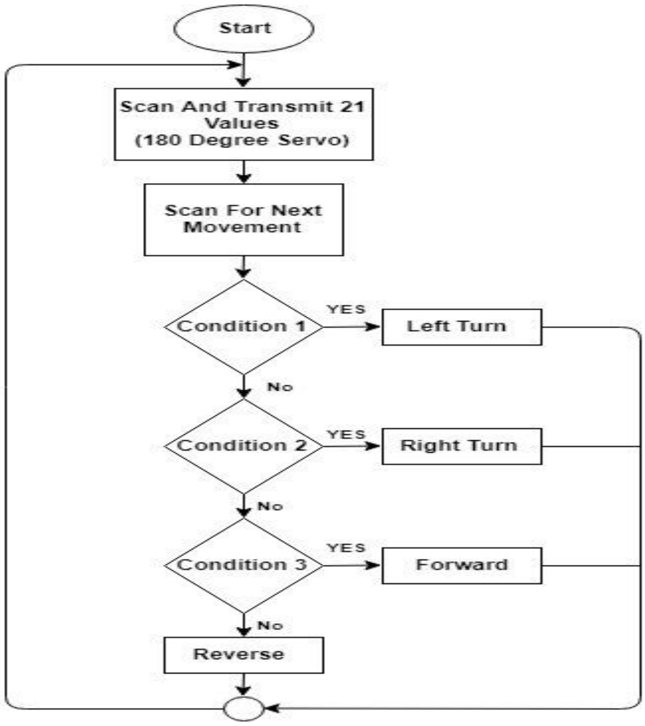

Fig. 3. Room mapping operation

B. Map Generation

The values stored in the excel file are provided as an input to the MATLAB program [5]. The program tends to decrease or increase the x and y co-ordinates with respect to the vehicle movement and plots the values accordingly to generate the final map of the area [6].

IV. RESULTS AND DISCUSSION

The distance values obtained from the sharp IR are transmitted to the computer through the Bluetooth connection. Fig. 4 shows the obtained distance values displayed over the Arduino serial monitor. The vehicle movement for the given conditions can be observed.

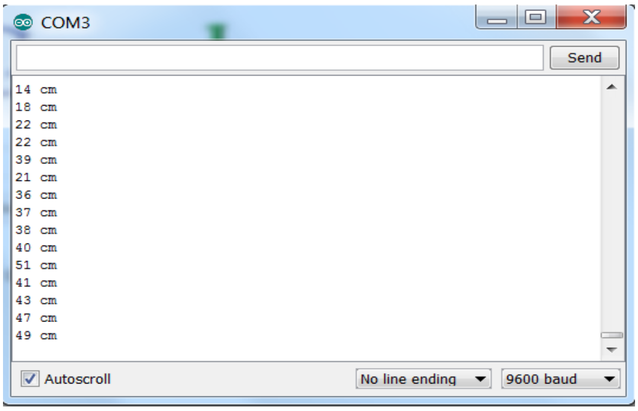

Fig. 4. Serial Monitor output

The final map is generated by the MATLAB code to which the obtained distance values are provided as an input [7]. The code plots the values obtained and also eliminates any redundant values, i.e., values greater than the range of the IR sensor. Fig. 5 shows the map generated. The absence of one of the edges of the obstacles placed or the lack of continuity in the plots in few regions of the generated map is due to the distances obtained at these points are above the range of the sensor and are treated as noise. Fig. 6 shows the prototype developed in this study.

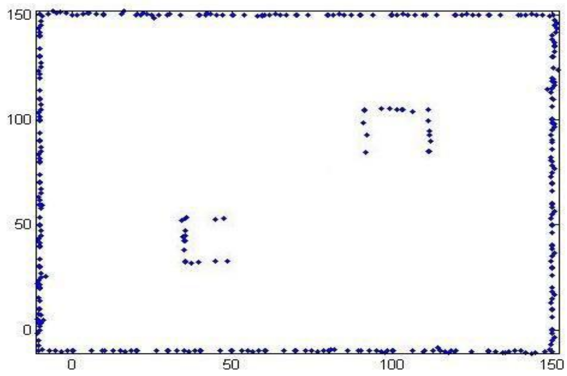

Fig. 5. Map Generated

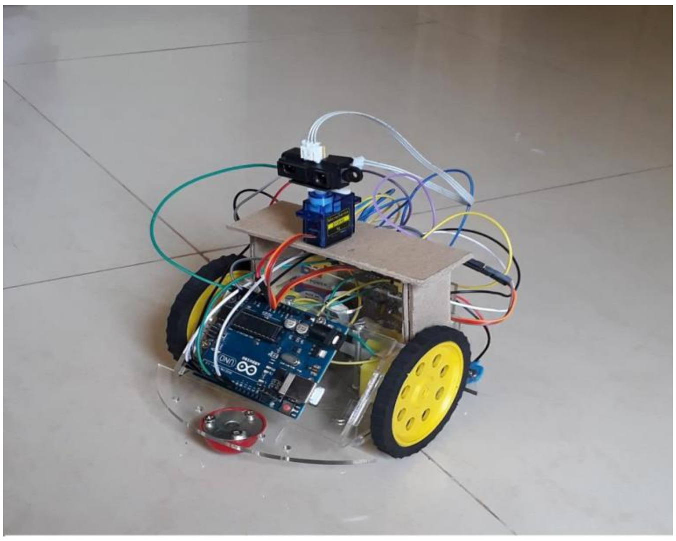

Fig. 6. Prototype of the model developed.

V. Conclusion and Future Scope

An “Autonomous Room Mapping Vehicle" is a vehicle designed and built in order to map its surroundings. Initially the vehicle maps the boundary along with obstacles present within the boundary using Infra-Red sensors. The vehicle moves pre-defined distances and after each time it scans for the presence of boundary, obstacle or free path. Noting these and transferring the distances of the position of boundary and obstacles to the computer. Based on this data a map of the surroundings is generated using a MATLAB program. The proposed concept can be used to develop maps of environments which are unknown or not feasible for humans to traverse in.

The future scope of this system would be using new and unconventional sensors or using cameras instead of sensors. Also, the chassis design can be modified or changed based on the terrain it has to operate in. Furthermore, neural networks can be used to avoid the need for human assistance for the working of the model and to allow the model to work outside the closed-world scenarios that they are trained in.

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