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Design and Implementation of Mapping Robot using Digital Magnetic Compass and Ultrasonic Sensor

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Abstract— **Robot mapping or trajectory plotting is the process of building an environment representation using mobile robot. In this paper we present a design and implementation of mapping robot using Digital Magnetic Compass, Ultrasonic Sensor and Arduino UNO which is having Atmel's ATmega328 microcontroller. We presents mapping of mobile robot in the indoor environment. The designed robot uses a metric, world-centric approach for mapping algorithm. Robot follows the wall while continuously sending its co-ordinates to the base station. Base station or map monitor has PC with bluetooth link connected with mobile robots and map is plotted on NI's LabView graph. The proposed approach is a simple and low-cost useful in robotic application to solve SLAM problem.**

Keywords*— *SLAM; Robot Mapping; Arduino; Trajectory Plotting, Digital Compass

I. INTRODUCTION

Role of sensing system is to detect the presence of objects and measure their positions. The objects can be neighbouring robots, obstacles and target. For interaction of the multiple robots, communication between robots is important to carry out specific task where one robot delivers orders or updates to other robots [1],[2],[3]. Multiple robots can be sent into an unknown building to produce a floor map [4]. Research is going on in the area of different mapping techniques over the time. Representing the geometry of the environment should have high accuracy [5]. A metric approach of mapping is one that determines the geometric properties of the environment. This representation is very useful, but is sensitive to noise. On the other hand topological approach is one that determines the relationships of locations of interest in the environment. World-centric mapping represents the map relative to some fixed coordinate system, while robot-centric mapping represents the map relative to the robot.

Simultaneous localization and mapping determines the location or pose of a robot and construct map of an unknown environment at the same time. Robot path and map are both unknown. There are various related works on localization, mapping, or both (SLAM). Most of this work focuses on exploring an information space of environment [6],[7],[8],[9]. An autonomous mobile robot must recognize its position and find the path for itself. Some of the SLAM mobile robot in the indoor environment uses digital magnetic compass and ultrasonic sensors. Multiple sensor technique makes use of ultrasonic sensor, infrared sensor, laser scanner, stereo camera, and electronic compass to solve SLAM problem [10], [11],[12], [13]. Robot need to plan a motion path through the environment to navigate without colliding with obstacles. Data obtained by ultrasonic range measurements is used to detect and avoid obstacles in environment [14], [15].

In this paper we present the design and implementation of trajectory mapping robot for SWARM application using Arduino UNO microcontroller. We presents mapping of mobile robot in the indoor environment using digital magnetic compass and ultrasonic sensors. We used metric, world-centric approach for mapping algorithm. Robot execute wall-following motions and can traverse the interior of the environment when following parallel to an edge while continuously sending its co-ordinates to the base station. The designed robot can be sent into an unknown building to produce a floor map. Base station has PC with bluetooth link connected with mobile robot. We used NI's LabVIEW software to plot map against co-ordinates send by mobile robot to PC base station.

The rest of this paper is organized as follows. Section II gives a description of hardware design of mapping robot. Section III presents algorithms implemented on robot and Section IV illustrates experimental results. Finally, Section V explains conclusions and future work.

II. THE HARDWARE DESIGN

The hardware assembly and specifications of mapping robot is explained in this section. Fig 1 shows the robot and its different modules. Fig 2 shows basic architecture block diagram of the robot. The robot uses Arduino UNO board as central processor and other input and output devices along with communication module and power supply.

Fig. 1. Mapping Robot : Actual Assembly

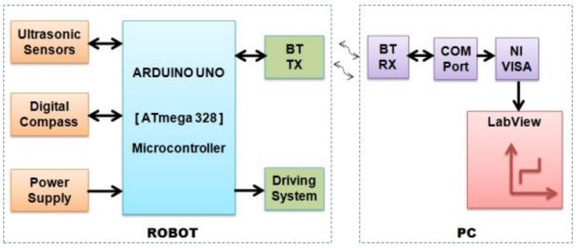

Fig. 2. Mapping Robot Block Diagram

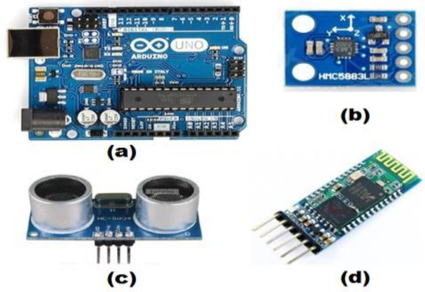

Fig. 3. Hardware contains of robot (a) Arduino UNO micro-controller (b) Digital compass - HMC5883L (c) Ultrasonic distance sensor - HC-SR04 (d) Bluetooth module - HC-05 module

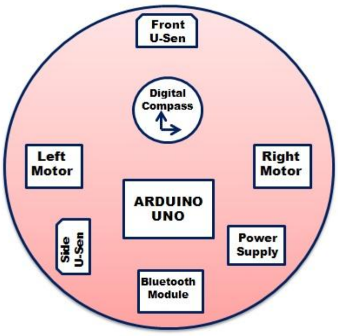

Fig. 4. Mapping Robot : Mechanical Assembly

Mapping robot has Arduino UNO development board which consists of Atmel's ATmega328 microcontroller with other electronic components which can be programmed using the software. It has 32 KB of flash memory, 6 Analog Input Pins, 14 Digital I/O Pins [16]. Robot has two kind of sensors used for navigation. Fig 3 (b) and (c) shows digital compass HMC5883L and ultrasonic distance sensor HC - SR04 respectively. HMC5883L is 3-Axis Digital Compass IC. The I2C serial bus allows for easy interface. It enables 1 to 2 Degree Compass Heading Accuracy. Working range of Ultrasonic ranging module HC - SR04 is 2cm to 400cm with accuracy of 3mm. Output voltage from sensor is corresponding to the detection distance from sensor to an object.

Robot has two DC geared motors for motion control. Two caster wheels are attached to front and back end of robot for support. Driving system of robot allows it to move forward, backward and rotate clockwise or anticlockwise. Communication between robot and PC is achieved using Bluetooth. HC05 module is an easy to use Bluetooth SPP (Serial Port Protocol) module, designed for transparent wireless serial connection setup. This robot has 12 Volts battery for powering of driving system and 9 Volts battery for Arduino. Base station or has PC with bluetooth link connected with mobile robot. PC has NI's LabVIEW software with NI's VISA driver to communicate with PC's COM port. Live co-ordinates send by mobile robot receives by PC and map is plotted on LabVIEW's graph Fig 4 shows mechanical layout assembly of designed robot.

III. ALGORITHM

Robot navigation and mapping algorithm is implemented on mapping robot. Motion path of robot is planed through environment to navigate without colliding with obstacles. We used concept of configuration space in which obstacle is considered to be expanded [17].

Fig 5 shows flowchart for mobile robot navigation. When robot turns on first it read value of its heading degree using digital compass. Then it looks for front and side obstacle distance using ultrasonic sensors. Designed robot follows wall to navigate through environment. Robot moves forward when there is no obstacle or wall at front and left side wall is present. Initial co-ordinates of robot assumed to be [0, 0]. As robot move it continuously updates and sends its co-ordinates to base station. Co-ordinates are updated using compass value and distance travel by robot. If front wall is detected then robot takes right turn and when both walls are not detected robot takes left turn. While in turning process robot uses compass value to make turn. After robot completes its 90 degree turn it stops and again read for both ultrasonic values.

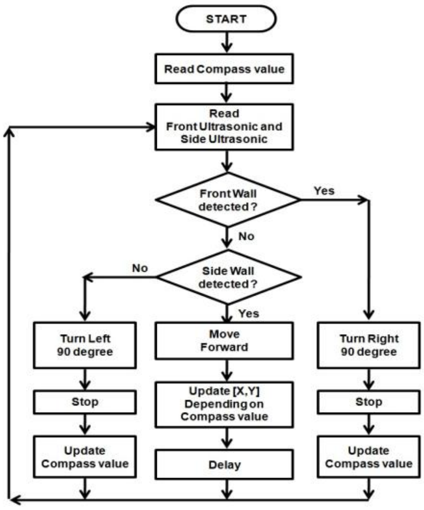

Fig. 5. Flow chart : Follower S-Bot Robot

When robot turns on it assumes itself to pointing towards north with heading degree of 0. At each corner it takes turn exactly to 90 degree. At each forward movement robot points towards one of the 4 directions. User need to select appropriate COM port of the PC and baud rate. Baud rate of 9600 is set at robot transmitter end and at base station receive end. Data received by bluetooth receiver appears at PC's COM port. Then using VISA driver it is read by LabVIEW. Robot sends co-ordinates in form of x0, y0, x1, y1, x2, y2,… now using comma separator and build array function X-Y graph is plotted on LabVIEW front panel.

IV. EXPERIMENTAL VALIDATION AND RESULTS

This section presents the experimental results of the above algorithm which is implemented on mapping robot. Experiments were performed indoor on plane surface. The objective of these experiment was to test the algorithms on designed robot and to observe mapping accuracy.

Fig 6 shows experimental result for open space type arena. Fig 6 (a) to (h) shows the snapshots of robot navigation for different events. Robot follow wall and it successfully navigate to interior of environment. Screen of PC/Laptop show output map created with co-ordinates of robot on LabVIEW graph. Hence we get representation of environment created by mapping robot. Experiment show expected results. Vale of sensors data can be observed on serial monitor of Arduino, from where compass value and ultrasonic sensor distance parameters can be used for debugging process.

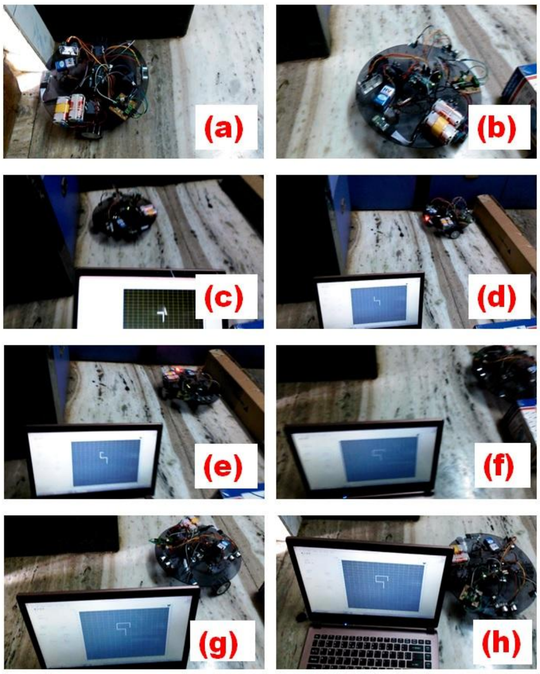

Fig. 6. Experimental Result : Navigation for arena

V. CONCLUSION AND FUTURE WORK

We presented hardware design of mapping robot using Arduino UNO controller board and other sensors and actuators. Obstacle avoidance with wall following algorithm is successfully implemented on robot for navigation. Robot successfully sends its co-ordinates to base station and mapping of unknown area is observed from experiment. The designed robot uses a metric, world-centric approach for mapping algorithm. All experiments show expected results. Future work would include multiple trajectory mapping robots can be used with inter-robot communication. Also large area mapping with use of onboard camera and GPS can be developed in future.

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