

MULTI ROBOT COMMUNICATION AND TARGET TRACKING SYSTEM AND IMPLEMENTATION OF ROBOT USING ARDUINO

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Abstract - SWARM robotics or multi robot systems is a novel approach to the coordination of large numbers of relatively simple robots which takes its inspiration from social insects - ants, termites, wasps and bees etc. 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, worldcentric approach for mapping algorithm. Robot follows the wall while continuously sending its co-ordinates to the base station. Target Tracking or Move to Goal algorithm is implemented on robot which allows one robot to reach target directed by other robot. Communication between robots is achieved using low cost CC2500 wireless transceiver module which is designed for very low-power wireless applications.

Key Words: Swarm Robotics, Multi Robot Communication, Target Tracking, Arduino.

1. INTRODUCTION

SWARM robotics is a concept to provide a robust robotics System using large numbers of identical robots inspired from social behaviour of animals or insects. Collective behaviour of robots comes from the interactions between individual robots and interactions of robots with the environment. With this approach it is easily possible to complete the tasks that are difficult to do with single robot. Research is going on in the area of sensor technology, motor technology, power supply technology, telecommunications technology, control technology and artificial intelligence technology for robotics. In SWARM robotics, cooperative task solving capability refers to self-organization and emergence. Self-organization refers to the SWARM's organization which comes from system itself and emergence means that the organization need to have local interaction between individual robots comes about decentralized way. For controlling motions of individual robot different coordination approaches have been reported such as task allocation, self-configuration, pattern generation. Instead of

investigation of a single robot system, researchers are working for exploration of coordination of multi-robot/SWARM systems as there are several advantages and application of multi-robot systems. These are; efficiency adaptability, fault-tolerance, scalability, and so on. Application areas of multi robot system are environmental monitoring, surveillance, distributed sensing task, oil cleaning, underwater localization and many more. Role of sensing system is to detect the presence of objects and measure their positions. The objects can be neighbouring robots, obstacles and target. Technical challenge is to develop and deploy real mobile robots at a reasonable cost. If data obtained from location sensing system is based on fixed global reference then it is absolute sensing and if it is based on local coordinates of a robot then it is relative sensing. Global positioning system (GPS) with central monitoring system is an example of absolute location sensing. Examples of relative location sensing include proximity sensors, cameras and received signal strength indicator (RSSI). A SWARMBOT is comprised of autonomous mobile robots called S-Bots. It discuss the self-assembling capabilities of the SWARM-BOT, this concept lies at the intersection between collective and self-reconfigurable robotics. 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. With advance in wireless communication technology it is possible to interface one device to other device. Advantage of communication between the robots is completing the task in efficient way. Wireless Local Area Network (WLAN) which is based on IEEE 802.11 standards and WPAN uses some technologies such as Infrared, Wireless USB, Bluetooth, and ZigBee for communication between sensors and electronic devices. Inductive Communication is one of the methods of communication for Millimeter-sized Wireless Robots. In this paper we present the design and implementation of S-Bot robot for SWARM application using Arduino microcontroller. In first algorithm, Multi Robot Communication is implemented to achieve Leader-Follower approach of SWARM navigation in which one robot follows other robot. Concept of co-operative navigation using master-slave SWARM robot is introduced. To achieve Target Tracking system, another algorithm is implemented on the S-Bot robot which allows one robot to track a location directed by other robot. Sender robot gives

target coordinates along with final angle position to receiver robot. After successfully calculating path trajectory receiver robot reaches to its goal configuration. The rest of this paper is organized as follows. Section II gives a description of the hardware specifications of S-Bot. The rest of this paper is organized as follows. Section II robot. Section III presents algorithms implemented on robots and Section IV illustrates experimental results. Finally, Section V explains conclusions and future work.

2. THE HARDWARE DESIGN

The hardware assembly and specifications of S-Bot robot is explained in this section. Fig 1 shows the S-Bot robot and its different modules. Fig 2 shows basic architecture block diagram of the S-Bot robot. The robot uses Arduino MEGA-2560 board as central processor and other input and output devices along with communication module and power supply.



Fig. 1. S-Bot Mobile Robot

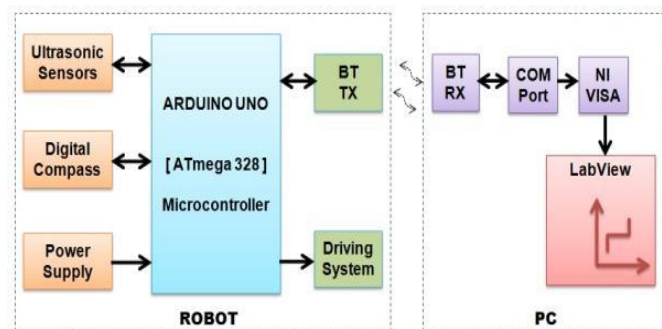


Fig. 2. Block Diagram

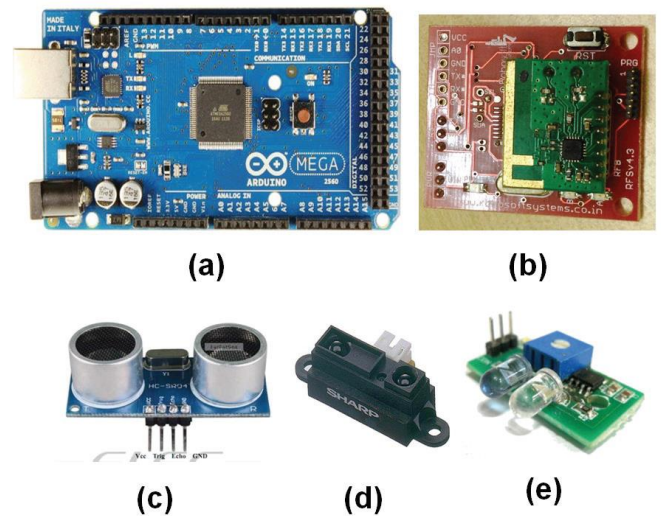


Fig. 3. Hardware contains of S-Bot (a) Arduino Micro-controller MEGA2560 (b) CC2500 Communication Module (c) Ultrasonic Distance sensor - HC-SR04 (d) Sharp Distance sensor 2Y0A21 (e) IR Proximity sensor

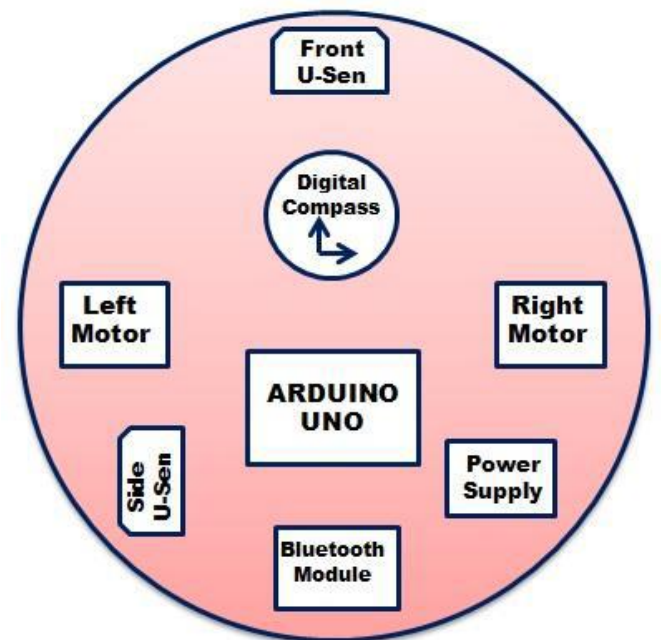


Fig. 4. Mapping Robot : Mechanical Assembly

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 coordinates send by mobile robot receives by PC and map is plotted on LabVIEW's graph Fig 4 shows mechanical layout assembly of designed robot.

2.1 Controller

S-Bot robot has Arduino MEGA-2560 development board which consists of Atmel's ATmega2560 microcontroller with other electronic components which can be programmed using the software. It has 256 KB of flash memory, 54 input and output pins including 16 - Analog pins and 14 PWM pins. Board can be connected to DC power supply up to 12V or it can be powered directly using a USB port without any external power. Internal voltage regulator regulates it to 5V and 3.3V. Arduino is an excellent open source platform. Arduino boards can be programmed using the Arduino Programming Language (APL) [16]. Fig 3 (a) shows Arduino micro-controller board.

2.2 Motion

S-Bot robot has two DC geared motors for motion control. One caster wheel is attached to front end of robot for support. Driving system of robot allows it to move forward, backward and rotate clockwise or anticlockwise. Along with DC motor S-Bot has servo motors for the movement of sensors. Distance sensors are attached to the rotary part of servo motors hence direction of sensors or sensory area can be changed using servo mechanism.

A. Sensory System

S-Bot robot has various sensors used for different application. Fig 3 (c) and (d) shows ultrasonic distance sensor HCSR04 and sharp distance sensor 2Y0A21 respectively. Working range of Ultrasonic ranging module HC - SR04 is 2cm to 400cm with accuracy of 3mm. Sharp GP2Y0A21YK0F is a distance measuring sensor with Distance measuring range from 10 to 80 cm. Output voltage

from sensor is corresponding to the detection distance from sensor to an object. Fig 3 (e) shows general purpose proximity sensor using IR emitter and IR receiver pair. It is very compact and has low power consumption. The range varies between 2cm to 15cm depending on ambient light. Using on-board potentiometer range can be calibrated.

2.3 Communication

In multi robot system for inter robot communication media is used to share information and make a collective decision. We have used CC2500 Serial Communication Module for communication as shows in Fig 3 (b). The CC2500 is a low cost 2.4 GHz transceiver which is designed for very low-power wireless applications. The module is designed to work for the 2400-2483.5 MHz ISM (Industrial, Scientific and Medical) and SRD (Short Range Device) frequency band. CC2500 has RS232 UART interface with variable baud rate, Programmable Device Address (255 per channel) and Standard configuration baud rate of 9600. CC2500 works up to range 30-50 meters for line of sight. We used this module as it works satisfactory up to 10 meters for indoor environment.

2.4 Power management

In SWARM application every mobile robot must have a sufficient battery power to complete a given task. This S-Bot has 12 Volts rechargeable battery for powering of all system. Using external charger battery can be charged as and when required.

3. 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. As shown in 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.

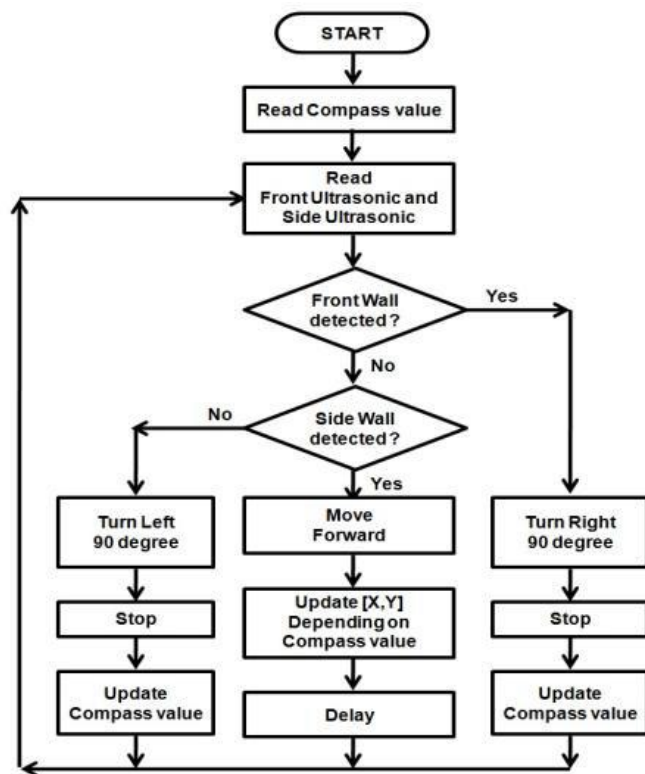


Fig. 5. Flow chart : Follower S-Bot Robot

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 $x_0, y_0, x_1, y_1, x_2, y_2$, now using comma separator and build array function X-Y graph is plotted on LabVIEW front panel.

4. 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.

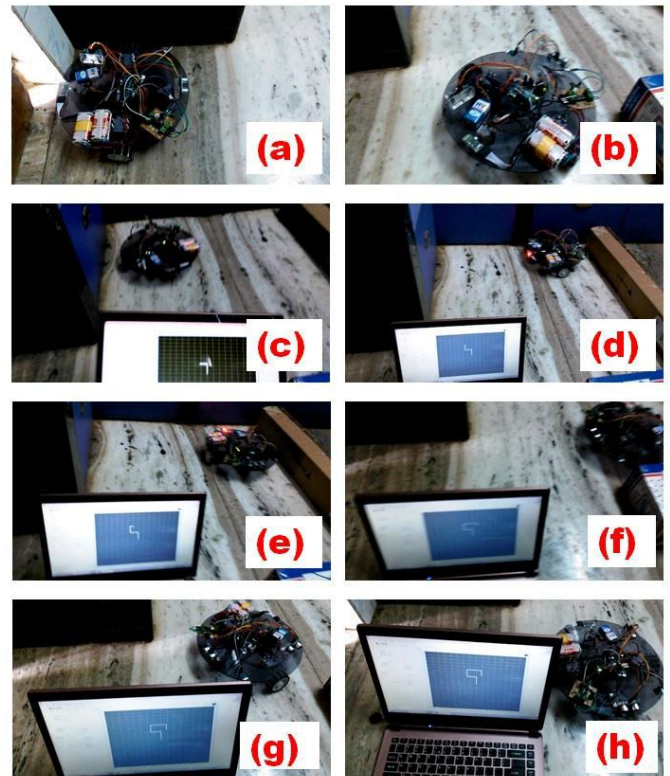


Fig. 6. Experimental Result: Navigation for arena

5. 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 on board camera and GPS can be developed in future.

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