International Journal for Innovative Engineering and Management Research
A Peer Revieved Open Access International Journal
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IJIEMR Transactions, online available on 18th Dec 2020. Link :http://www.ijiemr.org/downloads.php?vol=Volume-09&issue=ISSUE-12

DOI: 10.48047/IJIEMR/V09/I12/40

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Volume 09, Issue 12, Pages: 229-235.

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MULTI ROBOT COMMUNICATION AND TARGET TRACKING SYSTEM WITH CONTROLLER DESIGN AND IMPLEMENTATION OF SWARM 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, world centric 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.

Keywords: ***Multi level inverter, 5level inverter, MATLAB, RES network.***

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,

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researchers are working for exploration of coordination of multirobot/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.

OVER VIEW:

Robotics is a branch of engineering that deals with the design, construction, operation and application of robots, as well as computer systems for their control, feedback from sensors, and information processing. Mobile robots are used increasingly in safety critical applications namely production industries, defence and the military. Due to the time critical nature of such domains, automating the communication and coordination between these mobile robots are important. In applications, such as military operations, where the human operators themselves are under stress. In such situations, robots must be highly flexible and autonomous so that they can carry out complex tasks with minimal command effort from humans. Multi-Robot Systems can be generally characterized as a set of robots operating in the same environment. Multi Robot communication has a great significance. Multi Robot Systems can be generally characterized as a set of robots operating in the same environment. Multi-robot systems (MRSs) have a variety of applications, such as search and rescue in disaster hit areas, where many robots coordinate with each other to complete a task. Robotics industrial automation is changing the pace of production. Manufacturers of different companies are implementing some form of automation to become more efficient, safe and ultimately to increase revenues. It has many advantages including quality control, repeatability and faster cycle times. Implementation of master-slave framework in the robotic automation helps in increased efficiency and rise in production in case of robotics automation in production industries. So in our work we are focusing on developing autonomous mobile robots which are able to communicate and coordinate among themselves in the tmaster-slave fashion.

2. LITERATURE SURVEY

Xiao-Lin Long [1] discussed some of the wireless communication schemes and their applications that can be used in multirobot communication such as Implicit & explicit communication, Global & local communication and Synchronous & Asynchronous communication. Noa Agmon [2], evaluated the effect of different coordination schemes on the performance of the robotic team some of them are Uncoordinated, Tightly Coordinated and Loosely coordinated mechanisms and stated that Uncoordinated and Tightly Coordinated have better impact than loosely coordinated [3]. Avinash Gautam [4], proposed a system where a collection of two or more autonomous mobile robots working together are termed as teams or societies of mobile robots. In multi robot systems simple robots are allowed to coordinate with each other to achieve some pre-defined goals. Cooperation between two or more autonomous mobile robots is achieved using Implicit communication method and TCP protocol. A. Anand [5], described how a single robot is chosen as a central coordinator controls the movement of the rest of the robots. Master bot decides on the path to be taken and also directs the slave bots with the coordinates of the location to be reached. They have used ZigBee communication protocol is used for interaction among the robots.Punit Mittal [6], this paper resolves interference in accordance with the assigned priority to robots in a multirobot task allocation system (MRTA) [7]. New NFS algorithm for robot and Interference resolving strategy for a robot was used.Rajesh Doriya, Siddharth Mishra, Swati Gupta [8], described the Robot navigation is achieved by Particle

Swarm Optimization (PSO) that is used to coordinate the movement and control the communication of multiple robots. DhirajArunPatil [9], proposed an approach of leaderfollower where Multi Robot Communication is implemented and approach of SWARM navigation where leader robot guides the slave robots.Target Tracking or Move to Goal algorithm is implemented on robots which helps one robot to reach target directed by other robot. Communication between robots is achieved using low cost Nrf24L01wireless transceiver module which is designed for very low-power wireless applications.LiHan Chang [10], proposed a system where Conclusions are drawn that a multi-robot system can explore more quickly than a singlerobot system.

3. RELATED STUDY

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 [1],[6]. 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 [7]. Examples of relative location sensing include proximity sensors [8], cameras [9] and received signal strength indicator (RSSI) [10]. A SWARMBOT is comprised of autonomous mobile robots called S-Bots. Authors in [4] 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 [3]. 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 [4]. Inductive Communication is one of the methods of communication for Millimeter-sized Wireless Robots [5]. 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.

4. PROPOSED SYSTEM

After successfully calculating path trajectory receiver robot reaches to its goal configuration. In this section, the methodology procedures divided into two parts. The first part is a hardware implementation of the used parts, while the second is the software design details. Our proposed system is designed and developed to perform tasks in the master and slave fashions shown in figure where one robot will be guiding the other robot. Intruder monitoring is also achieved using ultrasonic sensor.

Hardware Model: In our paper both the robots operate with the help of the battery. Both consist of 12v battery which supplies power to different components of the system. Both robots consist of motors which are driven by L293D motor driver which in turn drives the wheels of the robot. Initially when the master robot starts moving, the slave robot starts following the master bot. With the help of the ultrasonic sensor present in the master robot, master robot gets to know if there are any obstacles on its way. If the obstacle was found it sends a notification to the slave robot t which directs the slave robot to change its direction of motion. Notification sending is achieved with the help of the transceiver model NRF24101.

Software Model: We have used Arduino application to carry out programming part of the project. Once the code is compiled and executed both the robots starts moving. Whenever the obstacle is found a notification is sent to slave robot in a wireless fashion. All these process happens automatically when a program is introduced into hardware and after execution. In our work we have the design of two robots both having different controllers. The master robot consists of Arduino NANO which is a 22 pin controller out of which 14 are digital input/output pins and 8 are analog pins. It's powered on 5V regulator which is connected to a 12V lead acid battery. The digital pins are used to drive the L298 motor driver for controlling robots directions. The motor is supplied with 12V lead acid battery.

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 shows basic architecture block diagram of the S-Bot robot. The robot uses Arduino MEGA2560 board as central processor and other input and output devices along with communication module and power supply.

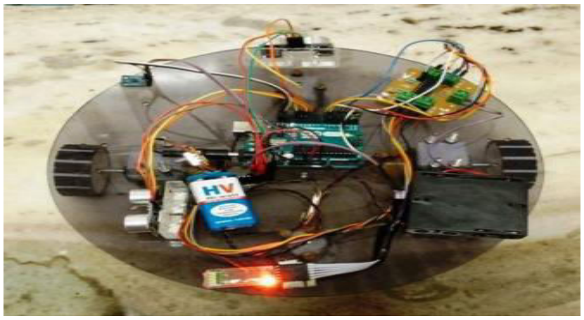

Fig.4.1. S-Bot Mobile Robot

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

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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 shows mechanical layout assembly of designed robot.

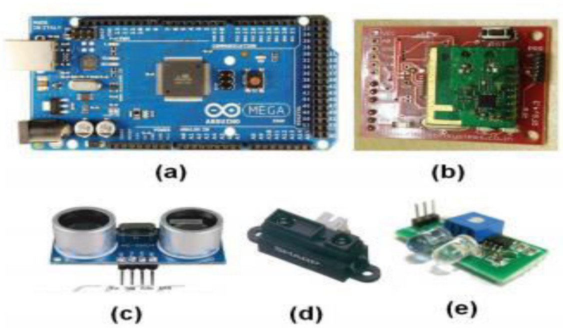

Fig.4.2. Hardware contains of S-Bot (a) Arduino Microcontroller MEGA2560 (b) CC2500 Communication Module (c) Ultrasonic Distance sensor - HC-SR04 (d) Sharp Distance sensor 2Y0A21 (e) IR Proximity sensor.

Task of leader robot is to continuously broadcast a character serially related to its motion. We have used four motions Forward, Backward, rotate right (clockwise) and rotate left (anticlockwise). Special character value has been assigned to each motion. This value is used to send serially for particular motion continuously with standard baud rate. While a receiver robot continuously receives a character value and depending on its value motions are performed. For successful communication baud rate at leader robot and all the follower robots should be same. Also channel used for all CC2500 maintained same.

5. CONCLUSION

Secured communication between robots is achieved. Effective Coordination between heterogeneous bots is considered. Obstacle detection and avoidance is achieved which makes this system suitable for real-time applications. Autonomous mobile robots are built which eliminates the need of external control. Leader-Follower approach algorithm for Multi Robot Communication and Move to Goal or Target Tracking algorithm were successfully implemented on S-Bot. Multi Robot Communication is observed from Leader-Follower experiment. In Move to Goal approach one robot guides other robot to reach particular location and angle. Both experiments show expected results. Future work would include use of other sensors (ultrasonic, sharp distance, IR proximity) which are implemented on S-Bot robot. Those sensors would be useful to avoid collision between multiple robots.

Further algorithm would include Simultaneous localization and mapping (SLAM) and pattern formation.

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