Journal of Advanced Research in Technology and Management Sciences (JARTMS)
Volume: 02 Issue: 04 ISSN: 2582-3078 July 2020
Available online at: http:// www.jartms.org

DESIGN AND IMPLEMENTATION OF ARDUINO BASED MULTI ROBOT FOR TARGET TRACKINGSYSTEM

[1]MARELLA TRIVENI LAKSHMI, [2]ASWANI LALITHA
[1]M.Tech Scholar, Dept. of ECE, Chalapathi Institute of Technology, Guntur district, A.P.
[2]Associate Professor, Dept. of ECE, Chalapathi Institute of Technology, Guntur district, A.P.

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. Local communication can be achieved by different types of wireless transmission systems. Different types of sensing system, Communication system and design approaches are used in SWARM robotics. This paper presents a controller design and hardware specifications of robot for SWARM application using Arduino MEGA-2560 which is having Atmel's ATmega2560 microcontroller. Implementation details are explained, and application of the multi-agent system is verified through algorithms. Multi Robot Communication is implemented to achieve Leader-Follower approach of SWARM navigation where leader robot guides the slave robots. 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 costCC2500 wireless transceiver module which is designed for very low-power wireless applications. The robot capability model and the task capability model are established, based on the distance between the robot and the target task and the matching degree between the robot capability and the task, a task allocation problem model is established to solve the problem of heterogeneous multi-robot collaborative task allocation.

KEYWORDS: multi-robot system, heterogeneous robots, SWARM Robotics, Multi Robot Communication, Target Tracking, Arduino.

* Correspondence Author

[1]MARELLA TRIVENI LAKSHMI

[2]ASWANI LALITHA

[1]M.Tech Scholar, Dept. of ECE, Chalapathi Institute of Technology, Guntur district, A.P.
[2]Associate Professor, Dept. of ECE, Chalapathi Institute of Technology, Guntur district, A.P.

I. INTRODUCTION

Fig. 1. Shows experimental setup for Multi Robot Communication or Leader-Follower approach. There is one leader and there can be one or more follower robots. The leader robot consists of an Arduino board as the centre controller of all the systems. Motion system consists of a DC motor driven with Driver. A communication system has CC2500 wireless communication Module. This Module work as communication between leader robot and follower robots. Follower robot just follows the movements of the leader robot by receiving commands via wireless modules.

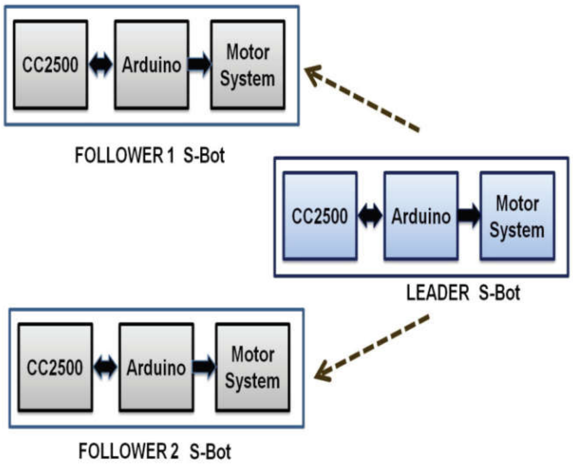

Fig.1: MULTI ROBOTCOMMUNICATION: SETUP

SWARM robotics is a concept to provide a robust robotics system using large numbers of identical robots inspired from social behavior of animals or insects. Collective behavior 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, and 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, under water localization and many more.

The word swarm is group of anything, inspired from nature such as swarm of ant, school of fish, swarm of bird we come up with swarm robotic concept. Swarm of ant works as group to find their foods and to protect them. Among this group of ants, there is one alpha ant. The whole group work under the command of this alpha ant. If there no alpha ant, the group can't perform any activity. So an alpha is required for group to be active. Same technique is used by other group such as group of bird or bee. In which an alpha controls the whole group.

Swarm robots are synchronicity of numerous robots with others also with its surrounding by direction of alpha. Alpha robot acts as controller which controls others. Slave's follow orders of master. Swarm robot is much productive also will complete the given task in less time compared to a single robot, since they are detecting gas spills location in different predefined areas of pipelines.

With the advent of the era of intelligent manufacturing, various types of robots are widely used in commercial and civilian fields, especially commercial multi-robot cooperative systems such as mobile transport robots, detection robots, and robotic arms. Therefore, considering the characteristics of heterogeneous robots, how to assign tasks to the robots and maximize the benefits of the entire multi-robot collaboration system is an urgent problem for multi-robot systems. First, According to Getkey's MRTA taxonomy, the modern multi-robot collaborative task allocation system can be defined as ST-MR-IA and MT-MR-IA, moreover, it can be defined as XD [ST-MR-IA] and XD [MT-MR-IA] in combination with the iTax classification. According to the research of Ayorkor Korsah et al., the multi-robot task allocation problem is usually solved by the market mechanism based method for the above-mentioned types of MRTA problems.

II. LITERATURE SURVEY

The majority of literature review papers on Multi-Robot Systems (MRS) focus on classifying the most fundamental aspects of an MRS, such as coordination and communication. The first, termed the coordination dimension, deals with the different classes of cooperation schemes, such as whether the system is centralized or decentralized, strongly cooperative (i.e. following a strict protocol), or weakly cooperative, among others. The system dimension classifies the existing types of communication schemes and team decomposition attributes. Similarly, in Parker classifies MRS according to their architecture, the heterogeneity in the team, the type of communication scheme adopted, and the different types of task allocation schemes. In this work, Parker also briefly reviews some works according to their application domain. However, the latter is not an extensive literature review of such works. A similar reviewing approach that categories works based on the foundation topics of MRS, namely coordination, task allocation and cooperation, is also adopted in. Furthermore, in contrast to these works, in Gerkey and Mataric focus on one particular aspect ́ of MRS, namely Multi-Robot Task Allocation (MRTA), and propose taxonomy of task allocation schemes. Alternatively, a literature review may also focus on particular schemes forming part of the main components in an MRS. In, Bernardine Dias et al. focus on classifying what they call market-based coordination approaches, which is a type of MRTA scheme. Such coordination schemes require the robots to bid for the tasks that they are able to perform. Furthermore, detailed reviews in the area of swarm robotics are properly surveyed in, while those reviewing biologically-inspired research include. We encourage the interested reader to refer to these works for more details.

Previous reviews proposed taxonomies that differ from those that we propose here. Dudek et al. (1993) chose swarm size, communication range, communication topology, communication bandwidth, swarm reconfigurability and swarm unit processing ability to classify the literature. Cao et al. (1997) used: group architecture, resource conflicts, origins of cooperation, learning, and geometric problems. Iocchi et al. (2001) adopted a hierarchical taxonomy: in the first level they considered aware versus unaware cooperation. The aware category is divided into strongly coordinated, weakly coordinated and not-coordinated systems. Works related to strongly coordinated systems are divided into strongly centralized, weakly centralized and distributed. A separate section is dedicated to applications of multi-robot systems. Gazi and Fidan (2007) chose to divide the literature into mathematical models, swarm coordination and control, and design approaches. Bayindir and ¸Sahin (2007) classified the literature according to five taxonomies: modeling, behavior design, communication, analytical studies and problems.

III. SWARM ROBOT ARCHITECTURE

The robot uses Arduino MEGA- 2560 board as central processor and other input and output devices along with communication module and power supply.

A. 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.

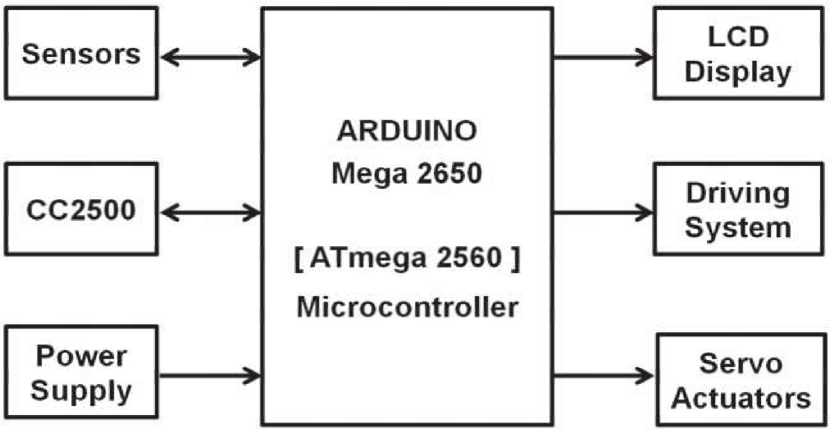

Fig. 2: block diagram of the s-bot robot

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).

B. 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 servomechanism.

C. 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.

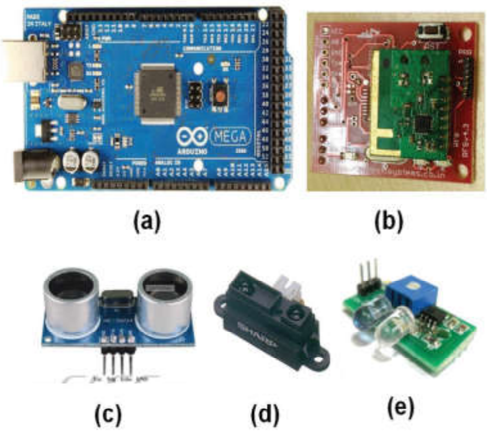

FIG. 3:HARDWARE CONTAINS OF S-BOT

(a) Arduino Micro-controllerMEGA2560 (b) CC2500 Communication Module (c) Ultrasonic Distance sensor -HC-SR04 (d) Sharp Distance sensor 2Y0A21 (e) IR Proximity sensor.

Working range of Ultrasonic ranging module HC - SR04 is 2cm to400cm with accuracy of 3mm. Sharp GP2Y0A21YK0F is a distance measuring sensor with Distance measuring range from10 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.

D. 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 lowcost2.4 GHz transceiver which is designed for very low-power wireless applications. The module is designed to work for the2400-2483.5 MHz ISM (Industrial, Scientific and Medical) and SRD (Short Range Device) frequency band. CC2500 hasRS232 UART interface with variable baud rate, Programmable Device Address (255 per channel) and Standard configuration baud rate of 9600. CC2500 works u p to range 30-50 meters for line of sight. We used this module as it works satisfactory up to 10 meters for indoor environment.

E. 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.

IV. CONCLUSSION

SWARM robotics or multi robot systems are a novel approach to the coordination of large numbers of relatively simple robots. Different types of sensing system, Communication system and design approaches are used in SWARM robotics. This paper presented a controller design and hardware specifications of robot for SWARM application using Arduino MEGA-2560 which is having Atmel's ATmega2560 microcontroller.

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