Communication and Coordination of Heterogeneous Robots

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***Abstract* – Robotics is the technology which is widely used in all the possible fields such as agriculture, military defense, patrolling, and automated industries and so on. As the automation of the systems is the trend that has been followed in many industries to obtain the results with increased efficiency, so we are incorporating automation in this work. Implementation of robots in the industries helps to achieve effective results. In our work the master and slave robot (centralized) methodology used in the multi-robot communication makes the slave robot to follow up their master and perform the specific task assigned to them. Then automating this communication process makes the difficult/risk tasks unmanned, preventing the accidents and results in completion of tasks quicker. Enhancing this using a wireless technology such as radio frequency technology makes the system to cover a wide range of areas on a comparison with other wired technologies. This work explains how the communication and coordination of a multi-robot where master is designed with Arduino Nano and slave is designed using Arduino Uno and is communicated with the help of nRF24L01 transceiver. The ultrasonic sensor used in the master detects any intrusion and alerts regarding the same to the slave and instructs it accordingly.**

Keywords – Intrusion, Multi-robot, Obstacle detection, Transceiver, Unmanned.

I.INTRODUCTION

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, defense 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. MultiRobot 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.

II. LITERUTER 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 multi-robot 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 co-ordinate 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 single-robot system. In addition, multiple robots are able to undertake teamwork and complex tasks. Master-slave approach and region exploration followed by goal to goal mode. The system consists of three main parts: a master controller, a communications layer, and multiple robots [11][12]. The multirobot system searches for signal sources, which can be crucial in realworld applications, such as rescue missions. Katsuaki Tanaka [13], In this paper they aim to design of the locomotion mechanism and uses stabilizer to develop a platform for confirming the basic locomotion performance. T. Bhavana [14],This paper aims at navigation of multiple mobile robots using leader follower approach [15][16][17] without collision of obstacles which is needed for many applications like formation of a geometrical pattern for a co-operative manipulation, collaborative mapping and exploration using Bluetooth communication. Mustafa Alberri [18], described a method where implementation of a generalized ROSbased architecture that is inter-connecting the multi-robotic heterogeneous systems for stable communication and data exchange is achieved. This architecture allows inter-robotic data exchange for communication between the vehicles by integrating embedded systems into the architecture structure.

III. METHODOLOGY

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 fashionas shown in figure 1 where one robot will be guiding the other robot. Intruder monitoring is also achieved using ultrasonic sensor.

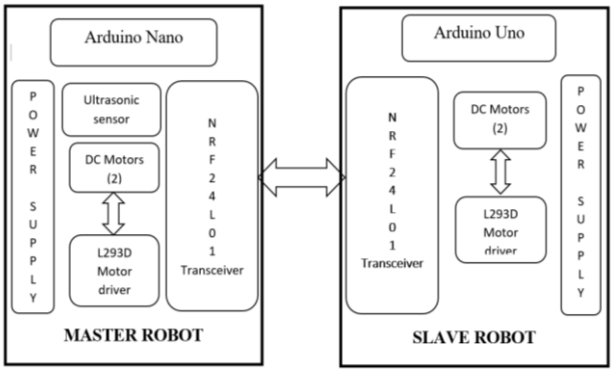


Figure 1. Block diagram of the heterogeneous robot system.

Hardware Model:In our paper both the robots operate with the help of the battery. Both consists of 12v battery which supplies power to different components of the system. Both robots consists 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 startsfollowing 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 slave robot consists of Arduino UNO as a controller which is based on ATmega328 micro controller as its brain. It is 8bit micro controller assuming on 16 MHz clock speed. It has 23programmable I/O lines.

A.Hardware Implementation

1. *Arduino UNO*

The Arduino UNO is an open-source microcontroller board based on the Microchip ATmega328P microcontroller and developed by Arduinofashion as shown in figure 2.The board has 14 Digital pins, 6 analog pins, and is programmable with

the Arduino IDE (Integrated Development Environment) via a type B USB cable. It accepts voltages between 7v and 20 volts. The ATmega328 on the Arduino Uno comes with pre-programmed boot loader that allows uploading new code to it without using an external hardware programmer.

Figure 2.Arduino UNO

2. *Arduino NANO*

The microcontroller used in the Arduino Nano is Atmega328, the same one as used in Arduino UNO fashion as shown in figure 3.It has 22 input/output pins in total out of which 14 of these pins are digital pins. Arduino Nano has 8 analog pins. It has 6 PWM pins among the digital pins and has a crystal oscillator of 16MHz. It's operating voltage varies from 5V to 12V. Flash memory of Arduino Nano is 32Kb which has preinstalled bootloader on it, also it takes a flash memory of 2kb. SRAM memory of this Microcontroller board is 8kb and it has an EEPROM memory of 1kb.

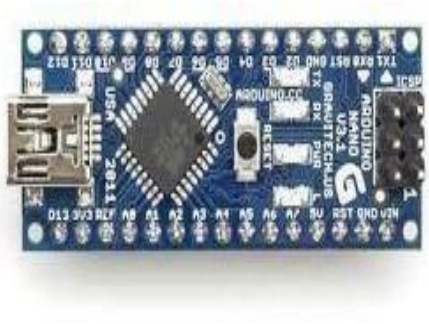


Figure 3. Arduino NANO

3. *Ultrasonic Sensor*

An ultrasonic sensor is an instrument that measures the distance to an object in the form of ultrasonic sound waves fashion as shown in figure 4.1.An ultrasonic sensor uses a transducer.

Figure 4.1 ultrasonic sensor

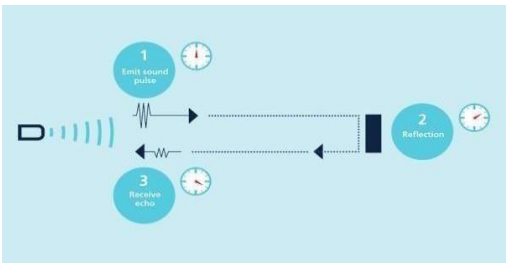


Figure 4.2 Working principle of Ultrasonic sensor

To send and receive ultrasonic pulses that relay back the information about an object's proximity. High-frequency sound waves reflect from boundaries to produce different or unique echo patterns. The working principle is as shown in figure 4.2.

4. *L293D Motor driver:*

L293D is a motor driver which allows DC motor to drive on either direction. L293D is a 16-pin integrated circuit which can control a set of two DC motors simultaneously in any direction as shown in figure 5.

Figure 5. L293D motor driver

It works on the concept of H-bridge. H-bridge is a circuit which allows the voltage to be flown in either of the direction since voltage need to change its direction for being able to rotate the motor in clockwise or anticlockwise direction, Hence H-bridge integrated circuits are ideal for driving a DC motor. In a single L293D chip there are two h-Bridge circuit inside the IC which helps to rotate two dc motor independently.

5. *nRF24L01 Transceiver:*

nRF24L01 is a single chip radio transceiver for the world wide 2.4 - 2.5 GHz ISM band. The transceiver is as shown in figure 6 consists of a fully integrated frequency synthesizer, a power amplifier, a crystal oscillator, a demodulator and modulator. Output power, frequency channels, and protocol setup are easily programmable through a SPI interface. Current consumption is low, only 9.0mA at an output power of -6dBm and 12.3mA in RX mode.

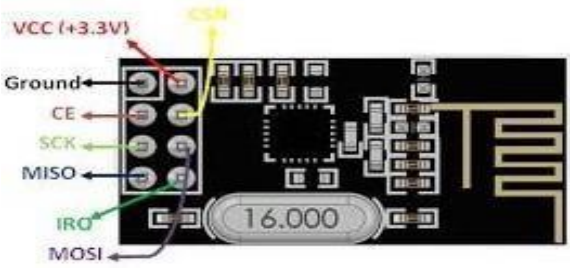


Figure 6..nRF24L01 Transceiver

B.Software Implementation

1.Arduino IDE

The Arduino integrated development environment (IDE) is an application which is written in the programming language Java and can be used in cross-platform. It originated on the IDE for the languages Processing and Wiring. It also has a code editor with features namely text duplication, searching and replacing text, automatic indenting, brace matching and syntax highlighting, and provides simple one-click mechanisms to compile and upload programs to an Arduino board. It also contains a message area, a console, a toolbar which helps to select functions and operation menus. The source code for the IDE is released under the GNU General Public License, version 2.

The Arduino IDE supports the languages such as C and C++. The software library from the Wiring project is supplied by Arduino,that provides many common input and output procedures. The sketch and the loop are the basic functions that is required by the user-written code, that are compiled and linked with a program stub main() into an executable cyclic executive program with the GNU tool chain, also included with the IDE distribution. The program is converted from executable code into text file by IDE.The loader program in the board's firmware loads program into Arduino board.

2.Sketch

A sketch is a program written using the Arduino IDE. Sketches are saved on the computer system as text files with the file extension. Arduino Software (IDE) pre-1.0 saved sketches with the extension pde. A minimal Arduino C/C++ program consists of only two functions:

- Setup (): This function is called once when a sketch starts after power-up or reset. It is used to initialize variables, input and output pin modes, and other libraries needed in the sketch.

- Loop (): After setup () function exits (ends), the loop () function is executed repeatedly in the main program. It controls the board until the board is powered off or is reset.

The Flowchart of the system is as shown in Figure 7. When both master and slave robots are powered on,if the master robot finds any obstacle in-front of it , the master robot turns 90 degree and also directs the slave robot to turn 90 degrees. If the master robot does not find any obstacle it moves forward and slave robot follows it.

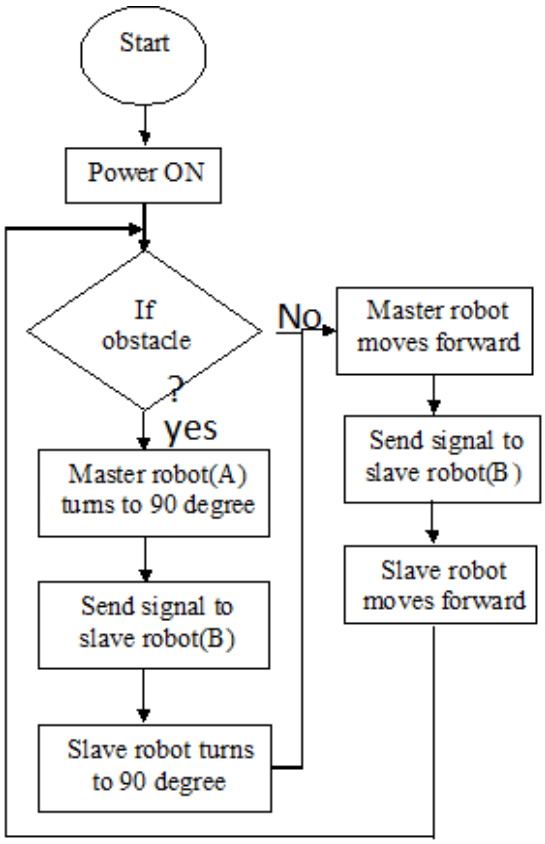
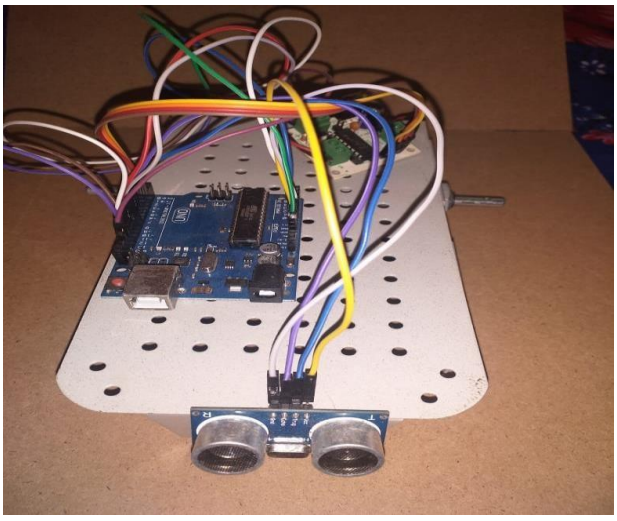


Figure 7: Flow Chart of communication of Heterogeneous robots

VI. EXPERIMENTAL RESULTS

The software and hardware are combined together to get the complete proposed system. The master robot and slave robot are shown in figure 8 a and 8 b respectively.



(a)

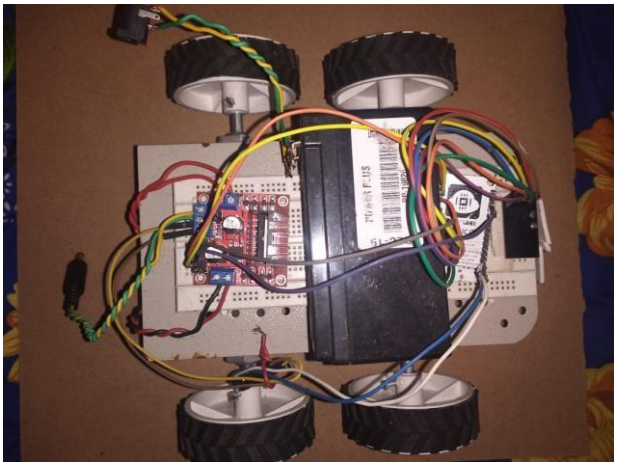


Figure 8: (a) & (b) Master and slave robots.

VI. 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.

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