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Design and Development of Automated Swarm Robots

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Abstract: Autonomous robots are programmable mechanical devices, which interact with the environment and can perform tasks without the aid of human interaction. Today most of the robots are used to repetitive actions, which are considered too dangerous for humans. They perform tasks in hostile environments, by carrying out tasks with speed and accuracy. Swarm robotics is an approach to the co-ordination of multirobot system, which consists of large number of simple physical robots. It is inspired by the emergent behaviour observed in social insects called Swarm Intelligence. Here is the one application which involves the concept of autonomous robots and swarm intelligence. It consists of master robot which tracks the path using IR sensor and even controls the action of slave robots through RF communication. Swarm robots travel from source to destination by avoiding the obstacles through the path using ultrasonic sensor. The individual robots are controlled using the microcontroller ATMEGA328P. It has many applications in agriculture, disaster management and military.

Keywords: ATMEGA328P, IR sensor unit, Obstacle avoidance, RF communication, XBEE.

I. INTRODUCTION

Robot Swarm is concerned with the design, implementation and control of a swarm of homogenous robots inspired by the emergent behavior observed in social insects called swarm intelligence. The main difference between the traditional robot and the swarm robot is that no one will direct and control the behavior of the robot; rather the robots will behave according to the surrounding environment and co-ordinates to accomplish the given task. It is possible to control swarm of robots, so that they co-operatively solve problems that go beyond the capacity of each individual. Large number of simple robots can perform complex task in a more efficient way than a single robot, giving robustness and flexibility to the group. The most remarkable characteristics of swarm robots are the ability to work co-operatively to achieve a common goal. It emphasizes a large number of robots, and promotes scalability by using only local communication. The local communication can be achieved by wireless transmission systems like radio frequency or infrared. One master and n number of slave robots are used which co-ordinate to perform desired task. Master will control the actions of slave robots via XBEE module. XBEE modules provide wireless end point connectivity to devices.

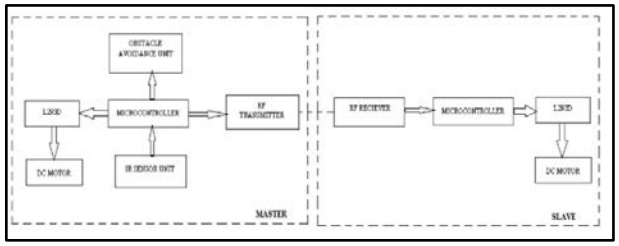

Fig 1. Block Diagram of Swarm Robot System

II. OBJECTIVE

The main objective in the design of swarm robot development is to achieve meaningful communication between the master and the slave robots. The path sensor unit should give the accurate output as that of the path laid. Master robot should move through the laid path, without any fault and transmit the same commands as assigned to the slave serially through Xbee to the slave. Slave robot should receive the serial commands through Xbee and execute the same.

III. HARDWARE IMPLEMENTATION

A. IR Sensor Unit:

IR transmitter LED and IR receiver LED is used in this design.

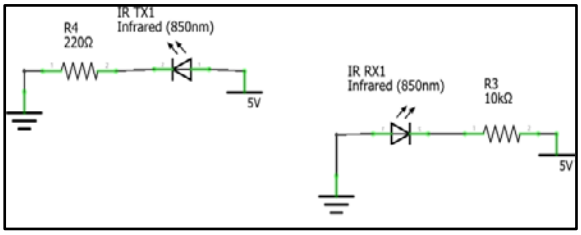

Fig 2. Circuit diagram of IR sensor unit

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The IR transmitter LED transmits infrared ray. If the path contains the black the black surface, as the black body radiation effect specifies the black color absorbs all the light and does not radiates any light. In the code, the movement of the wheel is specified for the low output i.e. if the path is black. Color white exhibits the properties opposite to that of the black color. The more precise the analog value that is read from the IR sensor unit, the more accurate is the path traced. The black color absorbs the light incident on it, therefore black surface absorbs the infrared ray emitted by IR LED as and there is no reflection of IR rays, because receiver IR does not receive IR rays. Then output was logic zero. The white color reflects the light incident on it, therefore white surface reflects the infrared ray emitted by IR LED, these reflected IR rays was received by receiver LED. Then output was logic one. According to the output of the IR sensor unit, controller ATMEGA328P takes the further decision. Not only the white and black combination; any color combination which gives more difference in the analog values can be laid as a path.

B. Motor Driver:

L293D is a typical Motor driver or Motor Driver IC which allows DC motor to drive on either direction. L293D is a 16-pin IC which can control a set of two DC motors simultaneously in any direction.

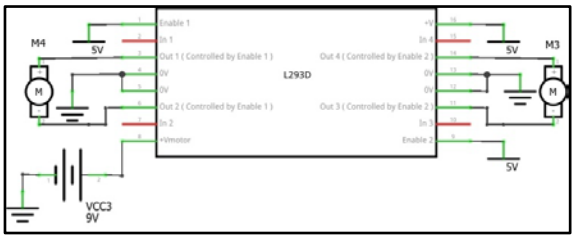

Fig 3. Circuit diagram of L293D motor driver

It works on the concept of H-bridge. H-bridge is a circuit which allows the voltage to flow in either direction. Voltage need to change its direction for being able to rotate the motor in clockwise or anticlockwise direction, hence H-bridge IC are ideal for driving a DC motor. In a single L293D chip there are two H-Bridge circuit inside the IC which can rotate two dc motor independently. Due its size it is very much used in robotic application for controlling DC motors. There are two Enable pins on l293d. Pin 1 and pin 9, for being able to drive the motor, the pin 1 and 9 need to be high. For driving the motor with left H-bridge enable pin 1 to high. And for right H-Bridge set the pin 9 to high. If anyone of the either pin1 or pin9 goes low then the motor in the corresponding section will suspend working. It's like a switch. There are 4 input pins for l293d.pin 2, 7 on the left and pin 15, 10 on the right as shown in the figure. Left input pins will regulate the rotation of motor connected across left side and right input for motor on the right-hand side. The motors are rotated on the basis of the inputs provided across the input pins as LOGIC 0 or LOGIC 1. The whole motor driver is controlled by the input from the microcontroller ATMEGA328P.

C. XBEE Module:

XBEE modules are embedded solutions providing wireless end-point connectivity to devices.

Fig 4. XBEE module

These modules use the IEEE 802.15.4 networking protocol for fast point-to-multipoint or peer-to-peer networking. They are designed for high throughput applications requiring low latency and predictable communication timing. So basically, XBee is Digi's own Zigbee based protocol. In layman's term, they are fairly easy to use wireless modules. In this design series 2c Xbee is used, which operates at 2.5GHz. It covers a distance of range up to 200 feet indoor and up to 4000 feet outdoor. As observed it covers less range of distance indoor as compared to that of the outdoor, because of the obstacles in the indoor unit. In the free space, the line of sight range is huge.

The radio frequency data rate is 250 kbps. 128-bit encryption is inculcated in this module for secured transmission of the data. The technique uses a 128-bit key to encrypt and decrypt data or files. 128-bit encryption is considered to be logically unbreakable. It is considered secure because it would take massive computation and virtually thousands of years to be cracked. It takes 2128 different combinations to break the encryption key, which is out of reach for even the most powerful components.

D. Obstacle avoider:

The HC-SRO4 sensor uses sonar to determine distance to an object like bats or dolphins do. It offers excellent non-contact range detection with high accuracy and stable readings in an easy-to-use package.

It sends out a high frequency sound pulse and then times how long it takes for the echo of the sound to reflect back. Using the time difference between the sent and the received sound pulse, it calculates the how far is the object from the sensor source using the equation;

$$\text{Distance} = (\text{Time} \times \text{Speed}) \div (2)$$

Fig 5. HCSR04 Sensor

Internally, the sensor initiates 10 microseconds TTL pulse to ping the trigger pin and sends a 8 pulse each of 40khz. If there is any obstacle in the path, the sound wave hits and reflects back. Echo pin in the sensor receives the sound pulse and calculates the distance using the above formula.

It can detect the objects at the range from 2cm to 400 cm or 1" to 13 feet. Its operation is not affected by sunlight or black material like Sharp rangefinders. Although acoustically soft materials like cloth can be difficult to detect. It can be used, where accurate and automatic distance measurement is required. It is more suitable for the environment, where optical sensors as unusable such as smoke, dust and similar.

IV. WORKING

The master and slave robots should be powered up using 9V battery.

The IR sensor unit in the master robot moves along the path by tracing it and returns the state i.e. HIGH or LOW. According to the state, the motor driver controls both the dc motors attached to the master robot.

Meanwhile, the master robot sends the commands corresponding to the actions carried out by it. It uses Xbee module to transmit the commands. The slave robot receives the command from the master robot and acts according to it.

V. RESULT

IR sensor unit gave the accurate output as that of the path laid. Master robot made its move through the laid path, without any fault. Master robot transmitted the commands serially through Xbee to the slave robots. As the main objective is to achieve meaningful communication between the master and the slave robots, Slave robot received the serial commands successfully through Xbee and executed the same.

VI. CONCLUSION

A master and slave swarm robot is designed. Robots are going to be the important part of the future. Robots as of now are working in a single hand system, whereas swarm is a multiple robot system. With all these applications and flexibility, it's safe to say that Swarm Robotics will play a big role in the future, possibly changing robotics as we know it. Considering the rapid advancement of technology, it's almost impossible to predict the timeline, and we may have proper functioning swarm of robots sooner than we think.

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