Swarm Robots for Environmental Monitoring and Surveillance

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Abstract- Swarm robotics is a field of multi-robotics in which large numbers of robots are coordinated in a distributed and decentralized way. Large number of simple robots can perform complex tasks in a more efficient way than a single robot, giving robustness and flexibility to the group. The wireless communication technologies are rapidly spreading too many new areas, including the automation and the importance of the use of wireless technologies in the data acquisition, building control, monitoring systems and automation of manufacturing processes will grow. The main aim of the Paper is to implement to develop an embedded system, which is used to control multi robots through wireless system and micro controller. This Paper is implemented ARM7-TDMI based LPC 2148 developed board interfaced with zigbee and ARM cortex- M3.

Keywords-Swarm-Robot, communication, ZigBee, ARM7LPC2148, LPC 1768.

I. INTRODUCTION

The main aim of the Paper is to implement and develop an embedded system, which is used to control multi robots through wireless communication system and micro controller. This Paper is implemented by ARM7-TDMI based LPC 2148 developed board interfaced with zigbee and ARM cortex- M3. In this paper two robots are controlled by using ARM 7 controller. A zigbee transceiver will be attached to the ARM controller and the two other will be attached to two robots individually. In this Paper there are two embedded systems based LPC1768 boards along with their robotic platforms. And one other embedded board is connected to Controller through which we will control the other two zigbee based robots. Whenever we want control the robot the commands are given from the controller and these commands are encoded and transmitted through zigbee and the code is received by zigbee and robot will be controlled. Depending upon the command received by the zigbee those robots will decide which has to move. Here the Robot1 detect the temperature by using temperature sensor. And the Robot2 detecting the gas leakages like LPG, alcohol, hydrogen smoke based on its fast response time. The automation and the importance of the use of wireless technologies in the data acquisition, building control, monitoring systems and automation of manufacturing processes will grow. The mobile robots and cooperative multiagent robotic systems can be very efficient tools to speed up search and research operations in remote areas. Robots are also useful to do jobs in areas and in situations that are hazardous for human. Robot can go anywhere that is not reachable by humans and can go into gaps and move trough small holes that are impossible for humans and even trained dogs. Aim of this Paper is to build a multi robot system, which could be able to send the environmental status.

II. PROPOSED ALGORITHM

Short-range wireless communication uses signals that travel from a few centimeters to several meters. Learn about some of the most widely-used types of short-range wireless technologies. In medium-range wireless communication travel up to 100 meters or so, while signals in wide-area wireless communication can travel from several kilometers to several thousand kilometers. Examples of short-range wireless communications are Bluetooth, infrared, near field communication, ultra band and Zigbee.

IR: The Infrared Data Association (IrDA) is an industry-driven interest group that was founded in 1993 by around 50 companies. IrDA provides specifications for a complete set of protocols for wireless infrared communications, and the name "IrDA" also refers to that set of protocols. The main reason for using IrDA had been wireless data transfer over the “last one meter” using point-and-shoot principles. Thus, it has been implemented in portable devices such as mobile telephones, laptops, cameras, printers, medical devices. Main characteristics of this kind

of wireless optical communication is physically secure data transfer, line-of-sight (LOS) and very low bit error rate (BER) that makes it very efficient. Infrared (IR) light is electromagnetic radiation with wavelengths that are just beyond those of visible light. The human eye can see light in the wavelengths from approximately 390-700 nanometers. Infrared light has wavelengths from 700 nanometers to 1 millimeter. This corresponds to a frequency range of approximately 430 THz to 300 GHz. Infrared is widely used in applications such as night vision devices and thermal imaging. Infrared essentially allows you to see heat, even when there is no visible light source. Infrared has been widely used for short-range wireless communications, in particular in the wavelength range from 1530-1565 micrometers. The range of the signal is limited and typically does not carry further than around 10 meters.
Bluetooth: Bluetooth is a type of wireless communication used to transmit voice and data at high speeds using radio waves. It is a standard protocol for short-range radio communications between many different types of devices, including mobile phones, computers, entertainment systems and other electronics. Devices need to be within approximately 10 meters of each other, and the typical data transfer rate is around 2 megabits per second (Mbps). Bluetooth signals operate in the 2.45 GHz frequency band While Bluetooth does not need a direct line of sight, the signals do not carry very far, and the devices need to be within approximately 10 meters.
Zigbee: ZIGBEE is an open technology developed by the ZIGBEE Alliance to overcome the limitations of BLUETOOTH and Wi-Fi. ZIGBEE is an IEEE 802.15.4 standard for data communications with business and consumer devices. It is designed around low-power consumption allowing batteries to essentially last forever. BLUETOOTH as we know was developed to replace wires and Wi-Fi to achieve higher data transfer rate, as such till now nothing has been developed for sensor networking and control machines which require longer battery life and continuous working without human intervention. ZIGBEE devices allow batteries to last up to years using primary cells (low cost) without any chargers (low cost and easy installation).
Tarang-P series: Tarang-P series modules are designed with low to medium transmit power and for high reliability wireless networks. The modules require minimal power and provide reliable delivery of data between devices. The interfaces provided with the module help to directly fit into many industrial applications. The modules operate within the ISM 2.4-2.4835 GHz frequency band with IEEE 802.15.4baseband.
Features: Zigbee Pro Complaint platform, Direct Sequence Spread Spectrum, RF Data rate: 250 kbps, Acknowledgement mode communication with retries.
Design Aspects: The main objective of the Paper is to control of two robots with control station, and receive the environmental conditions and gas leakages in areas
where human beings are unable to reach. This Paper is implemented using ARM7 LPC2148 for Main Controller and Individual ARM CortexM3 LPC1768 for ROBOT-1 & ROBOT-2 The Main Control station consisting of Power Supply unit, ZIGBEE Tarang F4, LCD and selection switches for ROBOT-1 and ROBOT-2.ROBOT-1 Consisting of 12 V Battery, Wireless Camera WS309AS-PAL for VIDEO/IMAGE Capturing, ZIGBEE Tarang-F4 for transreceiver of Data, Temperature Sensor LM35 and BUZZER. ROBOT-2 Consisting of 12 V Battery, ZIGBEE Tarang- F4 for transreceiver of Data, Gas Sensor MQ2 and BUZZER.
Design Approach:

Control station:

Control station mainly consisting of

- Transformer
- Zigbee Transceiver
- LCD
- ARM7 Controller
- Switch Module

Transformer: Here we used a step down transformer to convert 230 V AC signal to 9 V AC signal and a bridge rectifier along with filter circuit to convert from 9 V AC to 12V DC, by using LM 7805 Regulator will regulate the supply from 12 V to 5 V DC supply. This supply is given to the ARM controller.
Zigbee Transceiver: Zigbee transceiver is two way communications between two robots. It is connected from ARM 7 controller pins Tx and Rx (UART).
LCD: LCD is a 16*2 display connection from LPC 2148 ARM to view the output received by two robots.
ARM7 Controller: ARM7 core with LPC 2148 controller which is the control station main device it will control both the robots.

Switch Module: Switch Module consisting of eight keys used to select robots and controlling the robot directions. These are connected to port 0.14 to port 0.22 from LPC 2148 controller.

Control station:

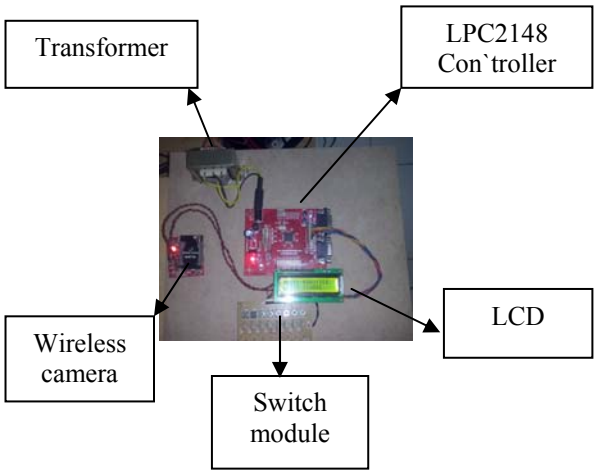


Fig 1: Control station

Robot1: This robot is having ARM cortex M3 processor and power is supplied by 12v battery, from ARM cortex M3 processor the Tx and Rx pins are connected to zigbee module for transmit/receive data, And driver IC L293D is used to drive DC Motor for controlling robot direction. Robot 1 is also having a temperature sensor and wireless camera, if temperature is exceeds normal value automatically buzzer which is connected to port 0.23 will be ON and the information is send to control station using zigbee transceiver. Wireless camera is also connected for capturing the images and video monitoring which could be observed in the PC.

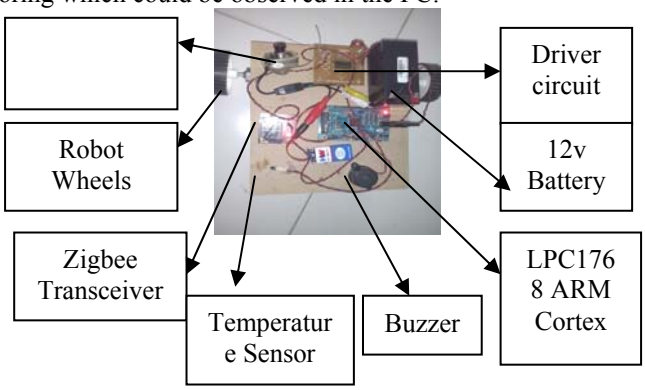


Fig 2: Robot1

Robot 2: The same procedure of robot 1 is follows to robot 2 and an extra gas sensor is connected to detect the gas leakages. That information will be sent to control station using Zigbee Transceiver.

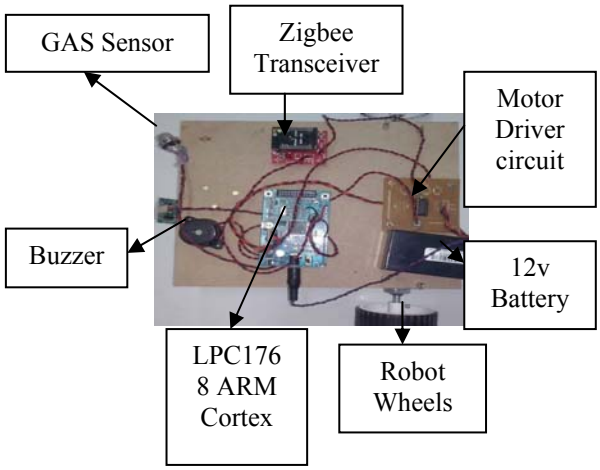


Fig 3: Robot2

Block Diagram and Flowchart:

Block Diagram:

Control station:

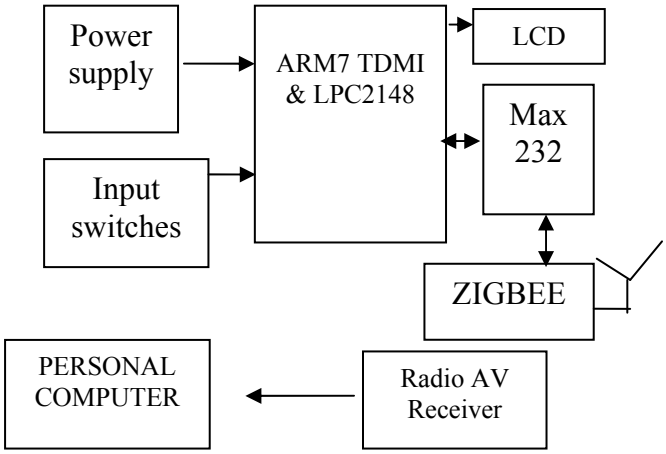


Fig 4: Block diagram of control station

Robot 1:

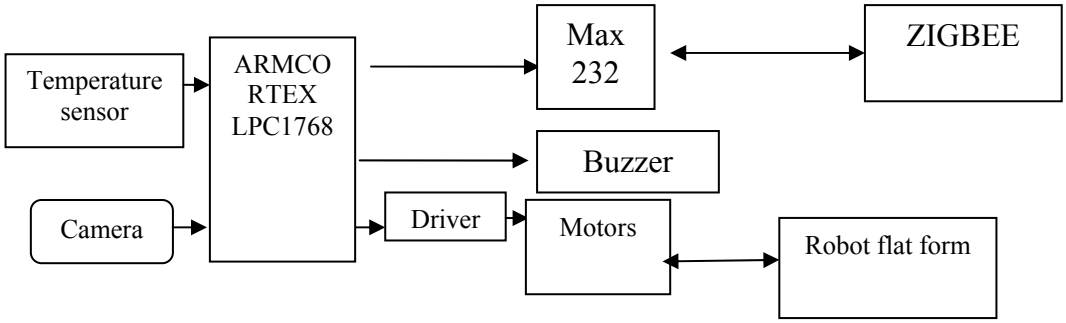


Fig 5: Block diagram of Robot1

Robot 2:

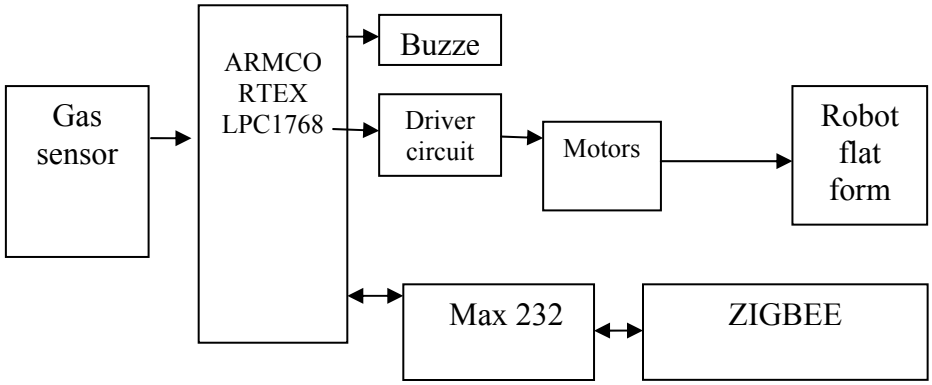


Fig 6: Block diagram of Robot2

Flowchart:

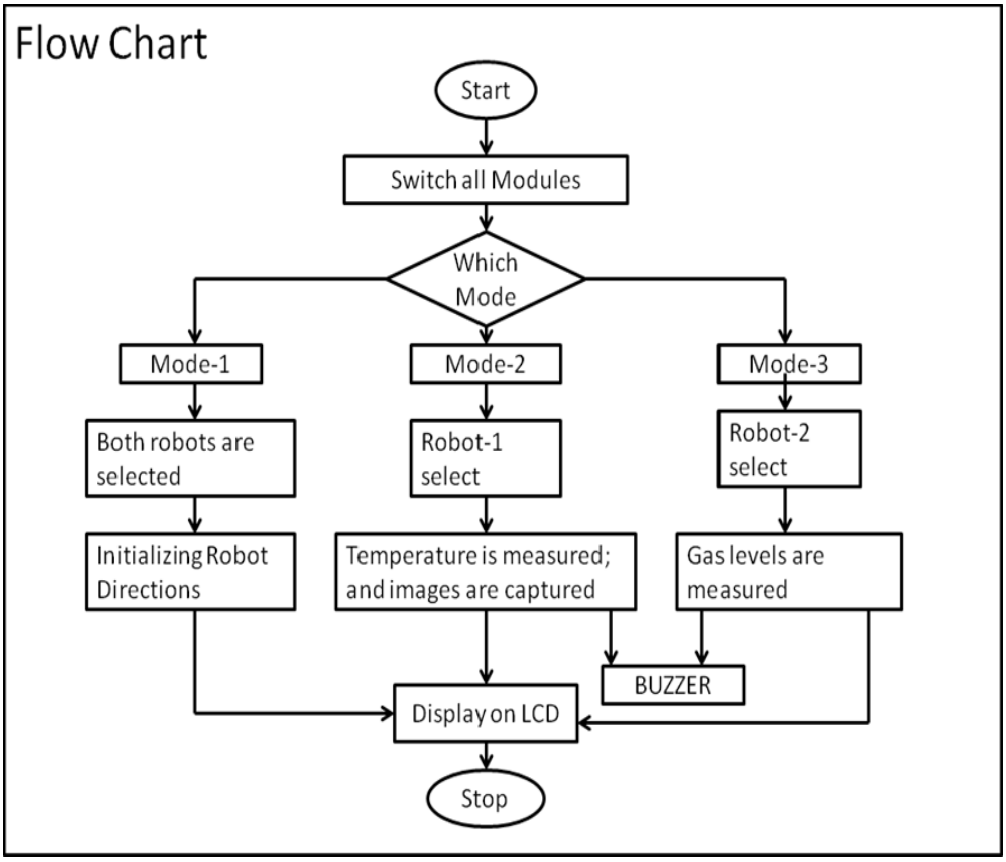
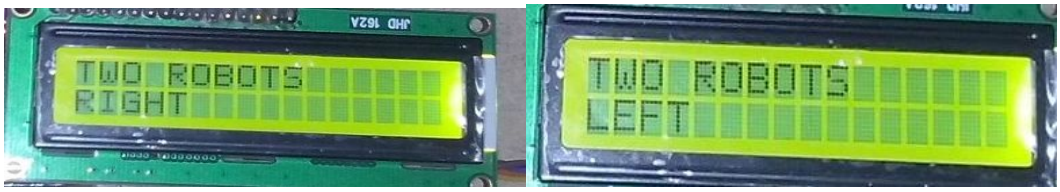
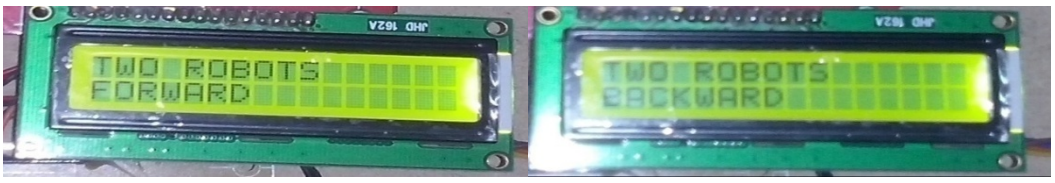


Fig 7:Flowchart

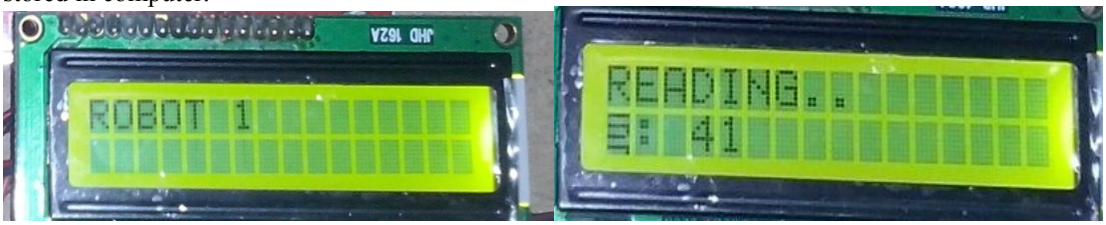
III. EXPERIMENT AND RESULT

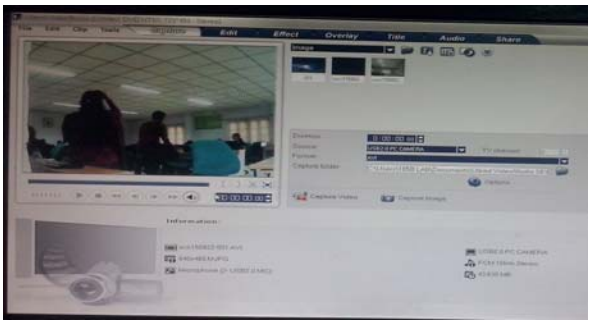
Test Plan: First the main control station , Robot1 and Robot 2 are programmed The main control station having 3 Modes and five key pins,1st mode is for selection of both Robots, 2nd mode is for Robot 1, 3rd key is for Robot 3, 4th key is for data reading, 5 to 8 keys for selection of motor direction.
Control station, Robot 1 and Robot 2 are having Zigbee Transceiver module for sending and receiving of data. *Robot 1* is having Temperature sensor & Wireless camera, Robot2 is having Gas sensor to monitor real time environmental conditions.By user input Control station send the selection command to selection of Both Robots, Zigbee send the command the same is received by both robots through Zigbee connected to both the robots and are ready for receiving the data command, Main Control station again send the data command for direction, the data command is received by both robots, DC motors of Robot 1 and Robot 2 will be move according to the data of received.By user input, Main Control station send the selection of Robots 1, Zigbee send the command the same is received by robots1 and is ready for receiving the data command, By user input, Main Control station send data command for reading of real time data, then temperature sensor on robot 1 read the real time temperature and same is sent to the Main Control station and is displayed on LCD.
The same procedure is followed for Robot 2 also. But the Robot 2 is connected with GAS sensor the output value is display on LCD in number of parts per million.
Test Result: LCD the output of the Robot 1 and Robot 2 sensor outputs are displayed and robots directions and images are capture from the camera.



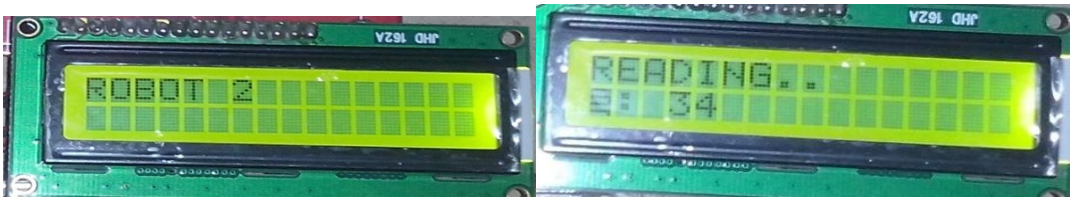


MODE 1: To select this mode switch 1 is pressed, then both the robots are selected. Robot directions are displayed on LCD i.e right, left, backward and forward directions.
MODE 2: Switch 2 is pressed to select robot 1 and the temperature is displayed on LCD. Images are captured and stored in computer.





MODE 3: Robot 2 is selected by pressing switch 3. The gas concentration in ppm is displayed on LCD.



RESULT ANALYSIS:

The hardware setup of the proposed system is shown in above Figure. The real time testing of the demo robot was done. Upon receiving the commands from Main Controller Unit, the micro controllers on Robot 1 and Robot 2 controls the motors to move in the intended direction. The same is displayed on LCD, The micro controller uses ARM7 TDMI LPC2148 microcontroller as its core. It has 45 general purpose I/O pins, two 10 bit ADCs, 12 MHz crystal oscillator, a USB connection and a power jack. It can transmit and receive TTL serial data. It also has SPI and I2C interfaces. According to the instruction given by user the sensor output are displayed on LCD and also the live video of environment conditions are displayed on PC.

IV.CONCLUSION

Based on the results, the objective of developing wireless robot using Zigbee protocol has been achieved. Zigbee has been proven as a practical solution for low cost monitoring and controlling devices. The Paper demonstrated that implementing Zigbee network protocol 802.15.4 with microcontrollers ARM7 can be done successfully. The wireless communication technologies are rapidly spreading too many new areas, including the automation and the importance of the use of wireless technologies in the data acquisition, building control, monitoring systems and automation of manufacturing processes will grow. Intelligent mobile robots and cooperative multi-agent robotic systems can be very efficient tools to speed up search and research operations in remote areas. These robots are also useful to do jobs in areas and in situations that are hazardous for human. They can go anywhere that is not reachable by humans and can go into gaps and move trough small holes that are impossible for humans and even trained dogs. The next step is to develop and implement a robot navigation system and also to build an autonomous robot, which with smart obstacle avoidance system.

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