Detection of Industrial Accidents using Biomimetics

Shraddha Thakkar, Sheldon Fernandes, Sharad Venkataraman, Amogh Waghmare, Karan Munyal

Abstract— It is of foremost importance in any industry to detect any flaws in the components that deal with volatile materials. The prevalent means to achieve this is through static observation points. A more efficient method would be to accomplish proper surveillance through mobile robot that can navigate through the complex maze of pipes. In this paper, a method to achieve the same has been proposed, based on the 'Biomimetics'. The proposed model has been implemented and results have been presented in the paper.

Index Terms -- Baud rate, Biomimetics, Zigbee.

I. INTRODUCTION

Verifying the proper connection between the different components across wide-ranging divisions is not just an aid, but an absolute necessity for many industries. This can be seen especially in those units that are involved in transport of gas via pipes. Any minor fault can snowball in to a huge crisis. That is why surveillance of such sites gains a paramount importance in such factories. However, static devices that inspect a particular part of the place cannot assure complete scrutiny due to the tortuous and convoluted pathways that may be present. There is a need for surveillance devices that can maneuver the meandering passage.

The robot designed is intended to meet the mentioned requirements. This robot is segmented into five parts that can turn and move ahead with agility. This is in close relation to the motion of snakes. It can be controlled wirelessly. The accompanied gas and temperature sensors detect Liquefied Petroleum Gas (LPG) leakage and ambient temperature respectively. The data acquired by the sensors is transmitted to a computer system through a Zigbee (XB24) module. A Closed Circuit Television (CCTV) module incorporated in the device transmits information wirelessly to a receiver which can be connected to any display device.

In Section II, the 'Biomimetic Principle' is explained, from which the implemented robotic structure has been derived. Section III and IV give the basic outline of the proposed and implemented snake robot along with hardware description and discussion regarding the same. Section V and VI present the recorded Observations and Advantages of the implemented scheme, thus, explaining the utility of the robot.

Manuscript received October, 2013 .

Shraddha Thakkar, Electronics and Telecommunication, University of Mumbai, Mumbai, India

Sheldon Fernandes, Electronics and Telecommunication, University of Mumbai, Mumbai, India.

Sharad Venkataraman, Electronics and Telecommunication, University of Mumbai, Mumbai, India.

Amogh Waghmare, Electronics and Telecommunication, University of Mumbai, Mumbai, India.

Karan Munyal, Electronics and Telecommunication, University of Mumbai, Mumbai, India.

II. BIOMIMETICS PRINCIPLE

Biomimetics is application of designs from nature to solve problems in engineering, material science, medicine, and other fields [1]. The various sophisticated phenomena occurring in nature are actually based on simple processes. The arms of an octopus, for instance, are incredibly strong and supple. They lack any rigid structures like bones making the movements difficult. The unique tissue properties and the arrangement of muscles make them capable of mimicking even the most intricate movements of humans. Ground-breaking technological solutions, covering diverse arenas like soft materials, mechanisms and actuators can be created using this concept [2]. Nature abounds with similar mechanisms. Such an idea can be exploited to solve day-to-day problems. This is the basic principle of Biomimetics.

The complex conduits that connect the different units of industries can be navigated in a fashion similar to that of a snake. A snake thrusts its body sideways across the surface that act as resistance points. This propels the snake forward. The designed robot moves in a similar fashion. The sideway motion of the robot and the propeller causes it to move ahead.

III. PROPOSED SCHEME

The biomorphic device that we developed can be demarcated in two functional components. The first component is the Sensor Module that gathers the data through which effective surveillance can be carried out. The source of the accident may be located at an obscure place. The second component, namely the Motile Module, is designed to maneuver the robot through complex routes.

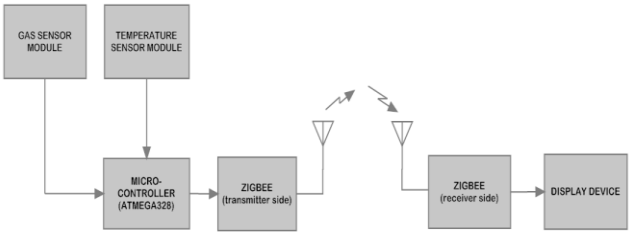

Figure 1: The Sensor Module

The Sensor Module as shown in Figure 1 consists of LPG Sensor MQ6 and thermistor TTC682. The analog data from these sensors are sent to a microcontroller ATMEGA328. The analog data is converted to 8 bit digital data and 1 stop bit using microcontroller. Using a Zigbee (XB24) transmitter module, the digital data is transmitted wirelessly. At the other end, the Zigbee (XB24) receiver module picks up the digital data and sends it to display device. Also, an audio and video live streaming module is incorporated in the device to send the camera output to a corresponding receiver module as illustrated in Figure 2. This enables a live evaluation of the site.

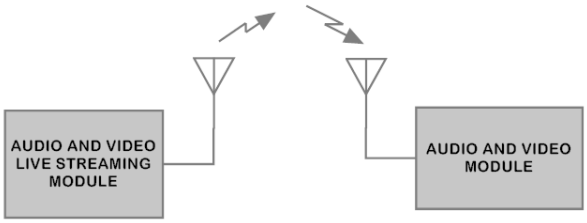

Figure 2: The Live Streaming Module

The core of the Motile Module is the motor that cause the robot to move. There are two servo motors that cause Left-Right Movement of the robot, mimicking the motion of a snake[3]. Further, two geared motors are present to make the robot to move ahead or backward. The motors are controlled by a microcontroller 89C51. Movement of the robot is controlled wirelessly with the help of a remote control consisting of a RF module.

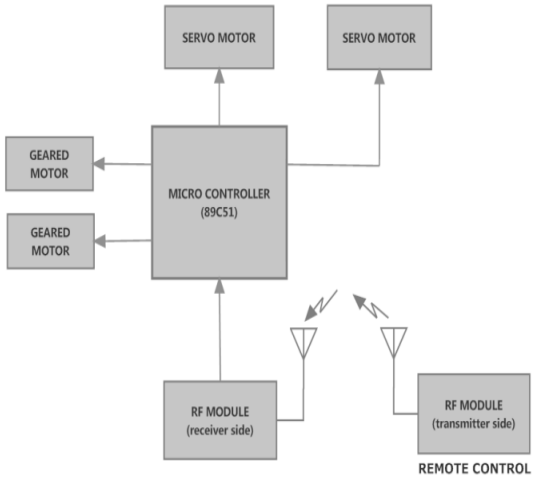

Figure 3: The Motile Module

IV. HARDWARE DESCRIPTION AND DISCUSSION

A. Sensor Module

As mentioned earlier, the sensor module has three basic parts. The gas sensor MQ6 is highly sensitive to LPG, iso-butane and propane. The detection concentration scope is between 200-10000 parts per million. The temperature sensor is the NTC Thermistor: TTC05 Series. The operating temperature range is between -40°C to 125°C [4].

The data from these sensors are transmitted using a Zigbee module. LPG gas and temperature sensors are interfaced with ATMEGA328. The output of the both these sensors are in voltage between 0 and 5 volts. These values are converted into digital values using the inbuilt Analog to Digital converter and stored in variables. These values are transmitted serially at a baud rate of 9600bps via a Zigbee module (XB24).

Since the Zigbee module (XB24) is configured to 'Broadcast mode' (using the software X-CTU), its transmission can be intercepted by any Zigbee module within range. The exact values of temperature and gas concentration are displayed on the computer screen.

B. Motile Module

The robot is segmented and it is required to move alternate sections of the robot in a direction opposite to each other. Such a mechanism is required for the robot to take sharp turns. So, the Motile Module has two servo motors that cause Left-Right movement of alternate segments.

The geared motors enable the forward and backward movement of the robot. The motion of the servo as well as the geared motors is controlled by the AT89S51 microcontroller. Circuit diagram of Motile module is shown in Figure 4.

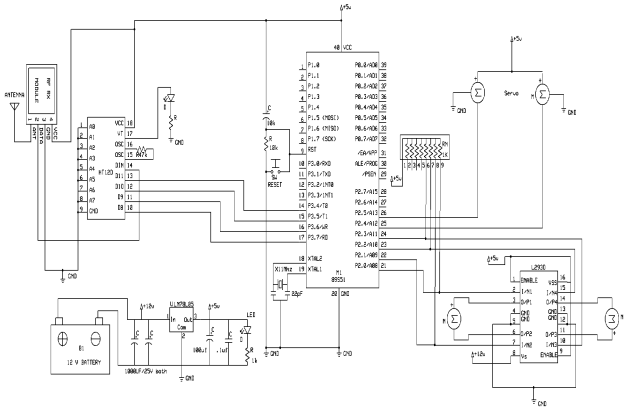

Figure 4: Circuit diagram of motile module

The motion of the robot can be controlled by a remote control as shown in Figure 5. The remote control circuit as shown in figure5 includes four motion controls; left, right, forward and reverse to direct the movement of the robot. This data from the remote end is encoded before transmission which is decoded at the robot end with the help of HT12 pair of encoder and decoder.

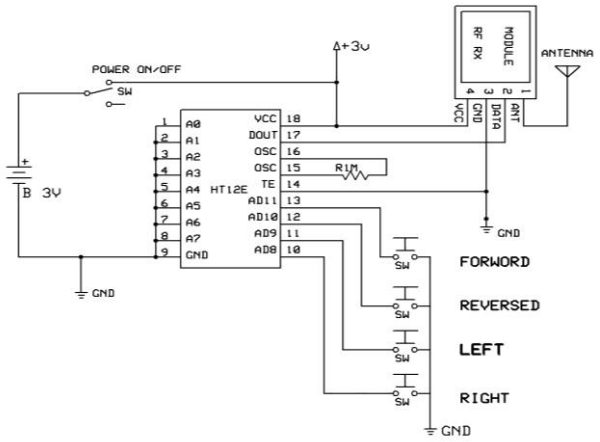

Figure 5: Transmitter Remote

When the push buttons are pressed, the commands relating to the desired motion is sent to the HT12E. It is a 12-bit encoder that is used to relay the command to the RF transmitter module.

Figure 6 shows the practical setup of the implemented model which illustrates the five segmented robot structure [5] with laptop used to display received data by Zigbee (XB24) module. Segment description is as follows:

- Segment 1 consists of the main motor, gear system and wheels, to drive the robot; and a head mounted wireless camera to stream audio and video.
- Segment 1 is linked to segment 2 using a servo motor to control the lateral movement of the snake. A battery pack to drive the geared motors, servo motors and the controller is mounted on this segment.
- Segment 2 is linked to the next segment again by using a servo motor. This segment holds the controller AT89S51 which receives data wirelessly to control the movement of the robot from a remote location.

- Segment 4 consists of the controller ATMEGA328 that receives data from the gas and temperature sensors mounted on segment 5 and transmits it via XB24 to a distant computer.
- All segment bases are mounted on caster wheels in order avoid any friction due to rough terrain.

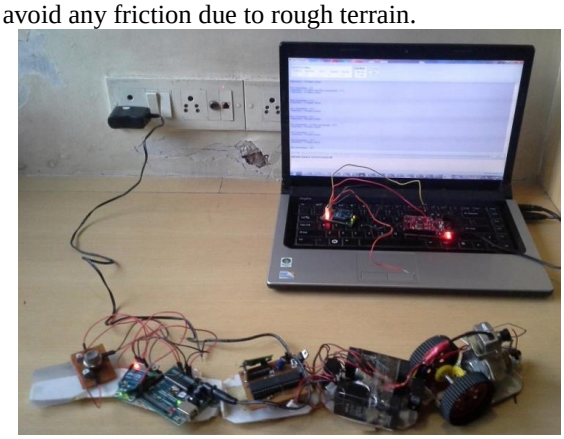

Figure 6: Actual Setup of Snake Robot

V. OBSERVATIONS

Data from temperature and gas sensors are routed to the computer system via a pair of Zigbee (XB24) modules. The actual setup is as shown in Figure 6. This data is logged into the computer system using the "Serial Terminal" software once every second. The Figure 7 shows the observations taken in normal conditions (at room temperature and no gas leakage). Thus it shows a minimum value of gas concentration (2 %), and the current ambient temperature (31˚ Celsius).

The value of temperature and LPG gas concentration was then increased using a cigarette lighter. Figure 8 depicts these observations. The value of temperature increases to 37˚ Celsius and gas concentration to 85%.

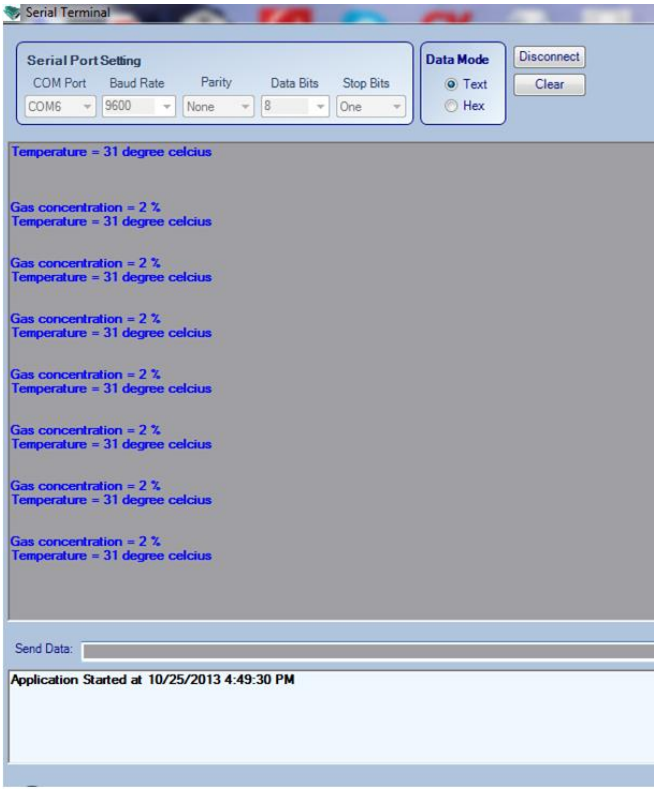

Figure7: Output under Normal Conditions

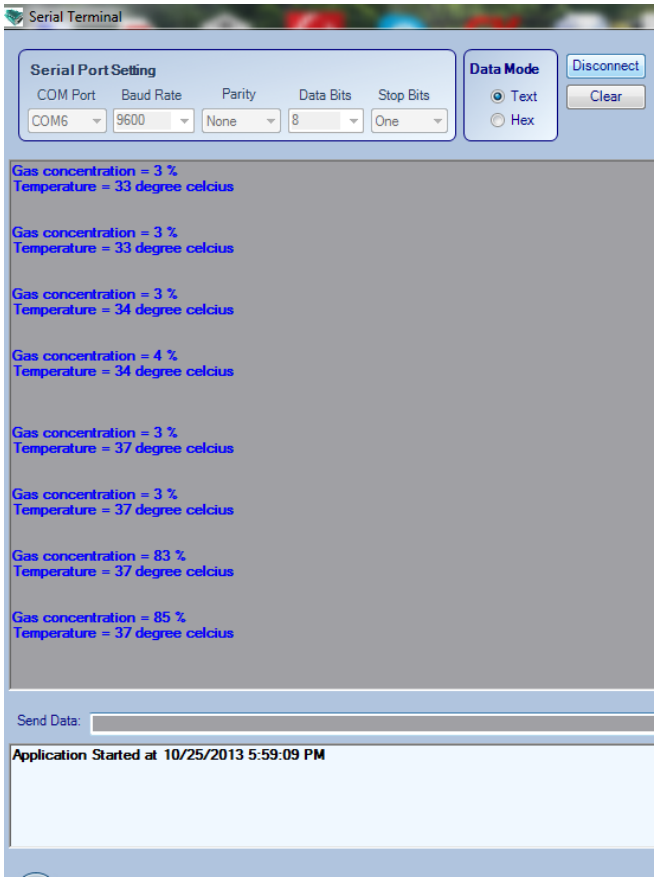

Figure 8: Output when Gas concentration and temperature are increased

VI. ADVANTAGES OF THE PROPOSED SCHEME

- Its pliant nature contributes in increasing the application scope of the robot in areas having uneven or rough terrain.
- The sleek structure enables the use of the robot in areas not suitable for humans to enter into; for example pipelines or certain industrial sectors with unsuitable environmental conditions for an individual to visit.
- The modular robotic structure consisting of number of redundant segments can be easily modified as per the requirements. It enables the easy replacement of out of order segments without disturbing the overall system performance.
- The digital data available from different sensors helps easy analysis of system conditions and hence contributes in taking quick actions required in the system.
- The live video through wireless camera helps controlling the robot movement to avoid any obstacles in its path or undesired collision and also aids in vigilance.

VII. APPLICATIONS

The ability of the snake robot to reach into confined spaces lends itself to many applications. Some of them are as mentioned below:

- Live audio and video streaming enables the use of the robot for various rescue operations.
- The incorporation of various sensors like gas and temperature sensors within the flexible robotic structure widens the scope in various industrial applications.
- The availability of continuous digital data from gas and temperature sensors using Zigbee Module helps increasing the performance efficiency.

- The supple nature of the robot in addition to the live tracking and sensor detection enables the use of this robot in areas like mining, medical field, nuclear power plants and several military applications.

VIII. CONCLUSION

A working model of the robot device that uses Biomimetics has been developed. This multi-function device has the ability to detect any gas leakage or any atypical temperatures. The capability to observe the test site through the camera is an added functionality of the device. It can be said that this device mimes the motion of a snake to achieve efficiency in taking sharp turns. The functionalities of the robot can be altered as per the use. Thus, a versatile device with wide ranging applications has been implemented using the principle of Biomimetics.

IX. ACKNOWLEDGMENT

The authors are thankful to Prof. Mahadeo Narlawar and Prof. Avinash Dangwani for their guidance and support.

REFERENCES

[1] Tom Mueller, Biomimetics: Design by Nature, National Geographic Magazine, April 2008

[2] B Mazzolai1, L Margheri, M Cianchetti, P Dario and C Laschi, Soft-robotic arm inspired by the octopus, IOP Publishing Ltd, Published 22 May 2012.

[3] Aksel Andreas, Transeth and KristinYtterstad Pettersen, Development in Snake Robot Modeling and Locomotive, Department of Engineering Cybernetics, Norwegian University of Science and Technology

[4] Cornell Wright et al, Design of a Modular Snake Robot, Proceedings of the 2007 IEEE/RSJ International Conference on Intelligent Robots and Systems, San Diego, CA, USA, Oct 29 - Nov 2, 2007

[5] Ross L. Hatton and Howie Choset, Generating gaits for snake robots: annealed chain fitting and keyframe wave extraction, http://www.cse.iitk.ac.in/users/cs365/2012/submissions/devvarat/cs365/projects/fulltext.pdf

Shraddha Thakkar is currently pursuing B.E in Electronics and Telecommunication (Mumbai University) from V.E.S Institute of Technology, Mumbai. She is currently an active Student member of societies like CSI, IEEE and ISTE and has served in the student council of CSI-VESIT. Her interested research areas are Wireless networks and Embedded systems.

Sheldon Fernandes is currently pursuing B.E in Electronics and Telecommunication (Mumbai University) from V.E.S Institute of Technology, Mumbai. He is currently an active Student member of societies like IEEE, CSI and ISTE and is currently in the student council of IEEE-VESIT. His interested research areas are RF circuit designing and Embedded systems.

Sharad Venkataraman is currently pursuing B.E in Electronics and Telecommunication (Mumbai University) from V.E.S Institute of Technology, Mumbai. He is currently an active Student member of societies like IEEE, ISTE and CSI. He is keen to pursue research in domains related to Embedded Systems, Wireless Networks and RF Circuit Design.

Amogh Waghmare is currently pursuing B.E. in Electronics and Telecommunication from V.E.S. Institute of Technology, Mumbai, India. He is an active student member of IEEE, CSI and ISTE. He has been a council member of 'Akashmitra', an organization devoted for popularization and research in the field of astronomy. His areas of interest are RF circuit designing and Wireless communication.

Karan Munyal is currently pursuing B.E. in Electronics and Telecommunication(Mumbai University) from V.E.S. Institute of Technology, Mumbai, India. He is currently an active Student member of the societies like IEEE, ISTE and CSI. His current area of research is Antenna and Wireless Communication.