Humanoid Explorer Robot: Design and Fabrication

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***Abstract*—Human beings are curious in nature. Exploring unknown places is not a new kind of adventure that many people opt for and often times this type of works lead people to danger without having proper data about the environment. This paper is on an autonomous humanoid explorer robot which can move around the area and attached some sensors with this robot those provide some important parameters of the environment such as temperature, relative humidity, amount of methane, Carbon-Di-Oxide, Carbon mono-Oxide. Also the robot is equipped with wireless 3G module for communication and collection of data. Later, the data collected from the robot are evaluated and analyzed to have a clear idea of the environment that the robot dealing with.**

Keywords—Explorer Robot; Humanoid Robot; Temperature Sensor; Humidity Sensor; Gas Sensor; Wireless Communication.

I. INTRODUCTION

The versatile usability of robots has brought the opportunity to employ them in situations where human presence may be required once, even though they were not fully safe for human, in some cases: extreme. However, as the development of modern robotics, the appeal has also increased to make them more human, at least in appearance. Even with great similarities in appearance to human, humanoid robots are still capable of doing all sorts of things their predecessors used to do, even with better panache. Since the beginning of time, humankind has explored the world ignoring the toll it has brought sometimes. In modern times, people has to go places for various reasons. In case of researching unknown terrain, humanoid robots and droids are especially helpful as they can provide the information we need without much of consequences. The rovers exploring planets are providing all sorts of data we seek continuously from thousands of miles away, which wouldn't be possible without them. For example in mine sectors like coal mines, copper mines etc. Everyday a lot of workers work in these mines in order to collect valuable mineral such as iron, coal, copper, petroleum etc. These mines are not always of user friendly environment [1]. It can be mentioned that the temperature, percentage of humidity and presence of several types toxic gases such as Carbon-Di-Oxide (CO_2) [2], Carbon mono-Oxide (CO) [3], Methane (CH_4) [4] may not provide an environment which would not be comfortable for people working there. In our paper we sought out the answers that can be provided with the help of a humanoid robot, which can explore a certain area without human intervention where it is equipped with different sensors and wireless communication module. This paper also describes the ways to build the humanoid robot and also presented the data along with analysis, received from the robot during its exploration.

II. LITERATURE REVIEW

Over the last decades, many researchers have proposed different special purpose robots and systems for exploring unknown terrains. Some of them explained the necessity of obstacle avoidance robot for reaching a place by a robot with a shortest possible time and also described how to make them [5]. Obstacle avoidance robot using Arduino [6] is one, which is a robotic vehicle equipped with Ultra-Sonic Sensor and developed in such a way that has an intelligence built in it. By this it detects itself whenever an obstacle in its path. RAPOSA: Semi-Autonomous Robot for Rescue Operations[7], for implementation of this robot, they installed thermal camera and two web cameras in the front side of the body and additional sensors include gas, temperature and humidity sensors, web cams, light diodes, microphone and loudspeaker. For operating this robot they use wireless communication. By this robot operators can see and collect some important parameters about the environment. Temperature and humidity calibration of a low-cost wireless dust sensor for real-time monitoring [8], in this work, they introduced the design, calibration, and validation of a low-cost portable sensor for the real-time measurement of dust particles within the environment. This proposal based on low hardware cost and calibration based on temperature and humidity sensing to achieve accurate processing of airborne dust density. This dust sensor was designed by Sharp dust sensor, temperature and humidity sensor, Bluetooth Module and power module This device achieves high quality measurements at lower-cost solutions than commercially available wireless sensors for air quality. An android based automatic detection and indication robot [9] is capable to detect the LPG upon a leakage using LPG gas sensor and sends data of the place through wireless communication like Bluetooth. In 1996 to 1997 NASA sent the Mars Pathfinder [10] with its rover Sojourner to Mars. The rover explored the surface as, commanded from earth. It was equipped with a hazardous avoidance system. This enabled Sojourner to autonomously find its way through unknown terrain.

III. METHODOLGY

The development stages divided into two categories: Hardware and software development after the proper planning for the humanoid explorer robot. Figure 1. illustrates the whole process of this robot. Hardware development involves both Mechanical and Electronics components. For mechanical development, the stages are as follows:

- Model Design
- Development of Prototype Model and
- Hardware Model Development

For electronics components the stages are as follows:

- Circuit Diagram Design
- Simulation of Circuit
- Development of Circuit

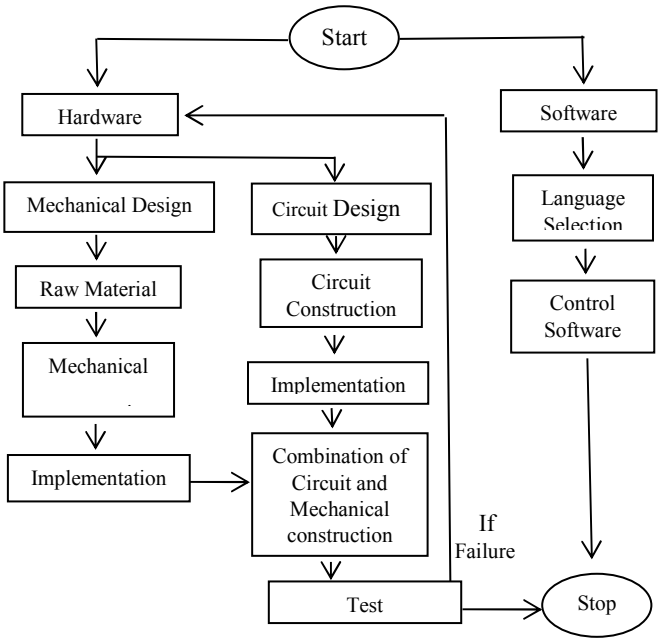

Fig. 1. Development Stages of a Humanoid Explorer Robot

IV. ADVANTAGES OF IMPLEMENTED HUMANOID EXPLORER ROBOT OVER PREVIOUS WORKS

- The robot can walk on unprepared terrain which is inaccessible for robots with wheels.
- It can step over obstacles whereas wheel based robot need to somehow travel over it or take a different path way.
- The sensors used in the robot are sensitive enough to respond in slightest atmospheric change.
- Gas sensor not only capable of detecting LPG but also can detect CO_2, CO and Smoke.
- This is fully autonomous in data transmission over long distance and controlling purpose which makes it convenient for places where human health is a big issue.

V. SYSTEM DESIGN

The proposed explorer robot is designed and built considering its better performance over long data transmission from the working environment so that the operators can have a clear idea about the environment. This system is divided into two segments: First one Robot module which is work as transmitting module and the next one is Ground Station which is work as Receiver module. Figure 2. & Figure 3. shows the overall design of the Humanoid explorer robot.

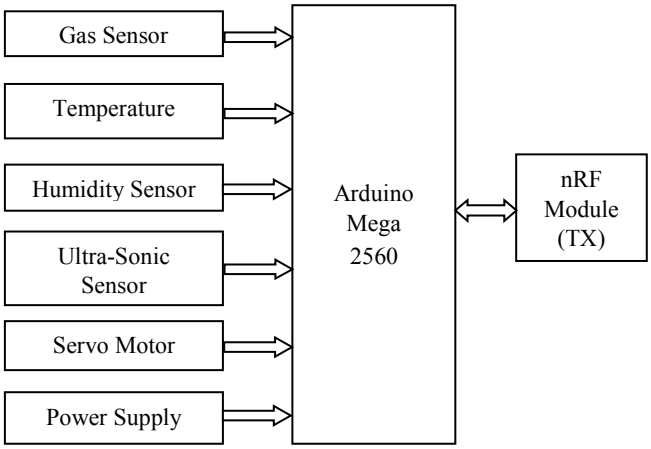

Fig. 2. Block diagram of the robot Transmission Module

In real time operation when the robot is used, it collects data continuously with the help of sensors and send to the ground station unit by using nRF module from where the robot is controlled.

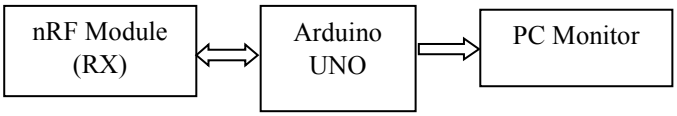

Fig. 3. Block diagram of Ground Station Unit (Receiver Module)

For constructing a humanoid explorer robot, it is important to consider both mechanical and electronic components. Combination of both components the robot is made.

A. Mechanical Construction

Figure 4. shows the body structure of the humanoid robot and it is made up with acrylic plastic sheet. The thickness of the plastic sheet is 0.5mm. We considered this sheet because it is flexible and light in weight also reduce the density of the robot which helps the robot for smooth movement. For the movement of the robot 6 metal gear servo are used in hips, knees and ankles of the both legs.

Fig. 4. 3D model of the robot

B. Electronic Components

For sensing, transmitting, receiving and controlling purpose some electronic components we have considered and they are listed below:

a. Arduino Mega 2560 and Arduino UNO
b. Temperature sensor and Humidity sensor (DHT-11)
c. Gas sensor (MQ -138)
d. nRF Module (nRF24L01)
e. Ultra-Sonic sensor (HC - SR04)
f. Servo Motor (MG-995)

C. Circuit Diagram Design

Figure 5. shows the circuit diagram of the explorer robot with transmitter module. For designing and partial simulation of the circuit we considered PROTEUS©. As there is no direct way to detect the presence of gas through simulation, so the simulation of the gas sensor was done by using pseudo binary input to the Arduino. Also data transmission from transmitter was conducted by RF module transmitter as there is no nRF module in Proteus. During implementation, we have modified the circuit diagram that we have designed in software. After successful design, simulation and implementation of the circuit it has been installed to the robot for the expected outcome that we have expected.

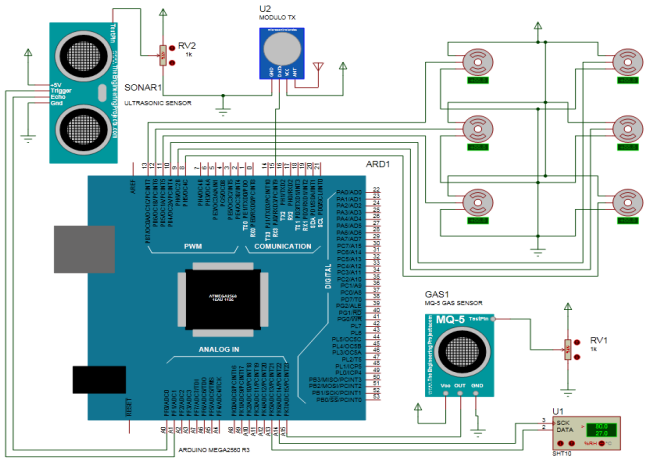

Fig. 5. Circuit diagram of the robot with TX module

The circuit of receiving end is also designed with Arduino UNO; it is connected with another RF module receiver. Figure 6. shows the circuit diagram of receiving end.

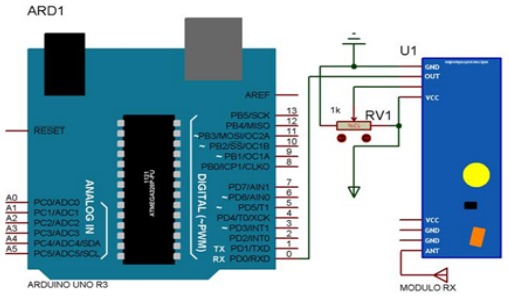

Fig. 6. Circuit diagram of the Receiver with RX module

D. Detection Mechanism of Different Gases

Gas detectors[11] indicate and measures the concentration of different gases such as toxic and combustible gases in the air. As detectors measure a specified gas concentration, the sensor response serves as the reference point or scale. When the sensors response surpasses a certain pre-set level, an alarm will activate to warn the user. There are two different gas sensors are used according to their gas detection principle. They are electrochemical gas sensors used for detecting CO, Cl_2, N and metal oxide semiconductor (MOS) is used for combustible gases [12].

VI. Fabricated Model of the Robot

After the implementation and combination of mechanical construction and electronic circuit diagram the final fabricated model was formed which is shown in Figure 7. where it contains control board (Arduino Mega 2560), TX module and sensors for sensing different parameters and transmitting to the receiving end of the environment. In this project, it is the most complicated part and designed in such way that it can perform accurately, the robot dealing with. The other part is receiving circuit, contains an Arduino UNO with an nRF module and collected data displayed on an LCD display (Display of Laptop). In Figure 8. illustrates the implemented ground station RX module circuit. It receives data from the robot (TX module) continuously

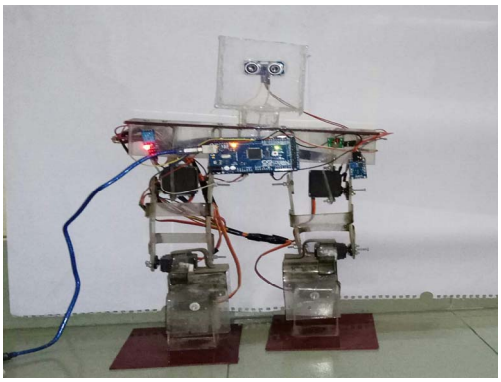

Fig. 7. Implemented model of the robot with TX module

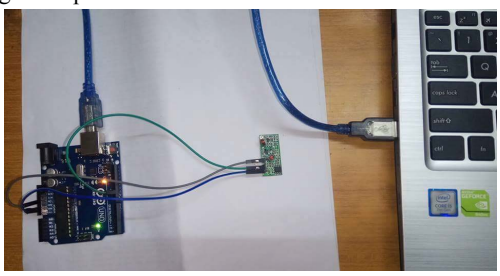

Fig. 8. Implemented Ground Station RX module Circuit

VII. Software Description

For mechanical design, electronic circuit design, collection of data from different sensors and real time analysis of these collected data different software have been used which are:

a) *Arduino:* It is an open-source electronics platform which senses the environment by receiving inputs from many sensors, and affects its surroundings by controlling lights, motors and actuators [13]. Two different Arduino board have been used for the robot. For TX module Arduino 2560 and for RX module Arduino UNO.

b) *Proteus:* For design and simulation of electronic circuit diagram this software is a very popular one. Because it is easy to design and simulate electronic circuit [14].

c) SOLIDWORKS: It is a comprehensive 3D design solution platform that adds powerful simulation and design [15]. In this paper it is used for designing 3D model of the robot.

d) *Cool Term:* It is a simple serial port terminal application (no terminal emulation) that can exchange data with hardware connected to serial ports from different sensors and preserve them in a text file [16].

e) MATLAB: It is a multi-paradigm numerical computing environment and fourth generation programming language. It allows matrix manipulations, plotting of functions and data etc [17]. In this project, it is used for plotting collected data from receiving module.

VIII. Experimental Data Analysis

The objective of this project was to build a such robot that can explore unknown terrain for example remote areas like coal mines, copper mines, iron mines, rescue operations etc. and gives important data about workplace environment. As it was not possible to conduct this environment in any area that we mentioned. For this, we create an artificial environment in a room to conduct this experiment. The collected data represented here:

a) *Temperature:* Figure 9. shows the variation of temperature inside a room. From the graph we can see the room temperature varied within 26□ - 27□.

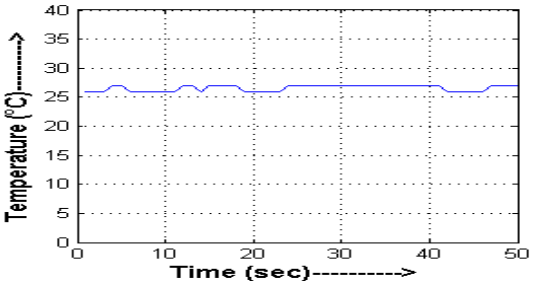

Fig. 9. Temperature variation with respect to time

b) *Relative Humidity:* Figure 10. demonstrates the relative humidity of the environment which is collected from humidity sensor. During experiment, it is remained constant at 82% and slightly varied from 82% - 83%.

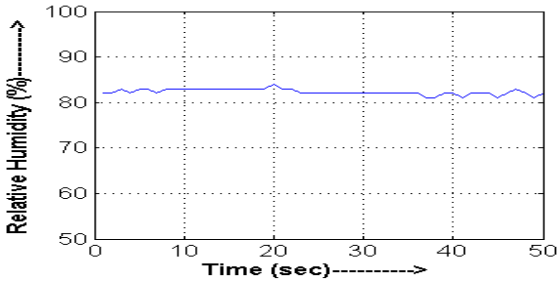

Fig. 10. Variation of Relative Humidity

c) *Methane Gas (CH_4):* Figure 11. shows the variation of methane gas (in ppm) with respect to time during the experiment. The amount of methane gas varied from 0-500 ppm. From the graph we can see that the sudden up rise in amount of CH_4 when we released the gas and then decrease of amount of gas over time.

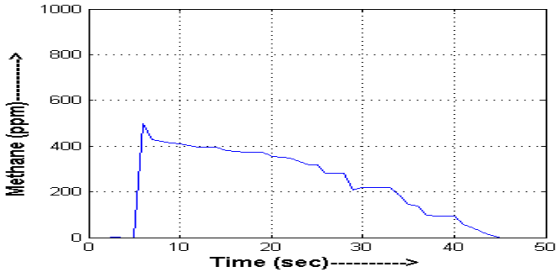

Fig. 11. Variation of amount of Methane over time

d) *Carbon-Di-Oxide (CO_2):* Figure 12. shows the variation of CO_2 (in ppm) during performing experiment. It is in the range of 0-600 ppm.

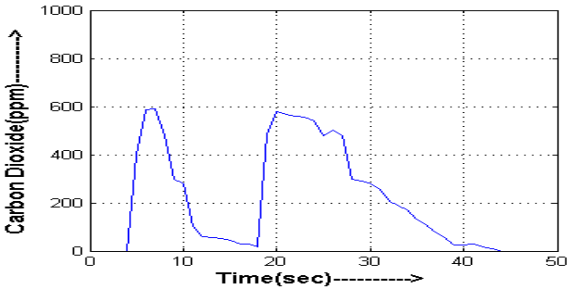

Fig. 12. Carbon-Di-Oxide variation with respect to time

e) *Carbon mono-Oxide (CO):* In Figure 13. shows the amount of CO (in ppm) variation in the room and it varied from over range 0-430 ppm with time.

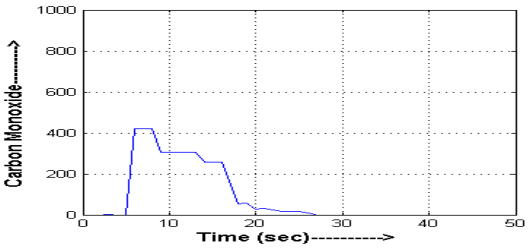

Fig. 13. Carbon mono-Oxide variation over time

IX. Conclusion

The experiment was conducted in a room so the actual outdoor environment is yet to be unveiled. Without it, this project covers all the design and development process of humanoid explorer robot. It is able to explore an unknown environment where it can measure Temperature, Relative Humidity, amount of Methane, amount of Carbon-Di-Oxide and Carbon mono-Oxide through sensors and transmit those data to the receiver. Then analyzed those data and give a clear idea about the environment. It might be a suitable one for unprepared terrain where wheeled based robots faced difficulties.

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