Smart Environmental Sensing Robotic Vehicle for the Internet of Things Framework

[1]Abina Latheef, [2]Riya Rajan, [3]Rangit Varghese
[1]PG Student, [2]Assistant Professor, [3]HOD
Mount Zion College of Engineering

Abstract - **Environmental monitoring using sensors form the base for most of the recent day research. The key parameters measured are temperature, humidity, pressure, light illuminance and gas concentration. Several smart solutions were proposed to monitor these parameters within the framework of Internet of Things (IoT). To access the complex location where conventional sensor deployment is limited, solutions based on Robotic Vehicle (RV) proves to be promising technology. Though several research articles are available on RV, it is still challenging to control the vehicle over the lost distance. Hence, we propose an environmental sensing robotic vehicle here based on 3G GSM network integrated to the IoT framework providing long-distance navigation control and environmental data collection. The proposed system is also equipped with smart energy harvester using commercially available solar cells to facilitate continuous powering when the vehicle is deployed for critical tasks.**

keywords - **Robotic vehicle, Internet of Things, Energy harvester, Environmental sensing**

I. INTRODUCTION

The variation in environmental parameters such as temperature, atmospheric pressure, humidity, air quality, and harmful gas concentration can be detected by environment monitoring. Information on such environmental parameters and data collection is known as Environment Monitoring. Monitoring plays a major role in environment planning and solving environmental pollution. While monitoring manually in affected area can be a cause for adverse health effect. Inorder to avoid such health risk associated with this new system is implemented for monitoring and protection. This system have intelligent data acquisition, communication and processing. The main aim of this system is to monitor the Environmental Parameters without any human intervention.

Recently, the new trending wireless sensor and ARM-based embedded system technology are getting integrated on a single board, intended towards the advancement of this system. The core part of the system is ARM (Acorn RISC Machine) which having the features high cost performance, code density, excellent period interrupt response and electricity consumption is low by using silicon chip. The Raspberry Pi 3B is an ARM based single board which has Broadcom BCM2837 64-bit ARM v8 Quad-Core processor and Arduino. It also has enough pins for GPIO and serial communication pin that can be connected to the number of sensors.ARM have these benefits that makes its effective selection for completing the system[1]. For greater understanding of environmental processes scientists use robotic system as a tool for data-gathering [2]. For the areas having harmful gas, monitoring climatic conditions, areas risky for humans such as remote places robots are used [3].

The user can access all the data that is collected from wireless connection and is sent to thingspeak iot platform. For analayzing the data that is collected a visual representation is performed that is real time cloud graphical represntation. The main advantage of this robotic system is that it is capable of monitoring without human involvement and also another advantage is that it will reduce environmental hazards which have risk to human. For remote monitoring of environmental conditions, mainly using wireless sensing methods, 3G GSM, Solar cell, robotics, IoT-based technologies. In order to tackle the problem of remote environment monitoring with avoiding health risks, it is imperative that the system should collect data via a self-sufficient robotic system and applicable observations transfer to a cloud server remotely.

II. RELATED WORK

In this environmental monitoring systems discussed, we use environmental sensors, robotic systems, IoT are been discussed inorder to get overall description about the work.

With recent advances in wireless sensor technology, low power single-board computers, and short-range communication technologies, remote sensing applications have improved towards solutions that encompass ubiquitous computing. A Cyber-Physical device was once proposed for environmental monitoring of ambient stipulations in indoor spaces [4]. Shete R. and Agrawal S. presents the framework for monitoring the metropolis environment. Low-cost Raspberry Pi used for implanting the system. However, no emphasis has given on particulate matter which left the environment monitoring system incomplete[5]. Biao Jiang and Christian F. Huacón developed a Cloud- based Environment Monitoring Smart Device (CEMSD) that monitors different environmental parameters such as air quality, noise, temperature, and humidity. The device collects and sends data from targeted measurement locations through a wireless network or cellular network to a cloud server[6]. The data related to temperature, humidity, light intensity, gas leakage, sea level and rain intensity are captured, and then the data is sent wirelessly to ThingSpeak using Arduino UNO. This work is focused significantly on the MATLAB visualization and analysis of the environmental data [7].

The authors present an IoT based real-time weather monitoring system using Raspberry Pi which is intricate compared to Arduino due to the programming language used and the Raspbian operating system [8]. The designed and developed a wireless network of sensors for environmental monitoring using Raspberry Pi and Arduino. They employed Xbee module to instrument the IEEE 802.15.4 standard for data collection from multiple sensor nodes at a base station (Raspberry Pi). This system can be extended to ensemble large scale applications, however in the present form, the system lacks cloud connectivity [9].

In order to deploy a scalable and remote monitoring system, an efficient platform that enables users to monitor their daily exposure to air pollutants by giving air quality information provided by various sensing infrastructure is proposed. The sensors periodically monitor air quality. The data can be monitored and accessed from anywhere using mobile phones or PC with Internet access. The implementation has sensors for air quality, CO, CO2, and temperature and humidity to monitor the environment around. The Raspberry Pi has been used to interact with the IoT platform and sensors. The Arduino Mega microcontroller is used for control and navigation of the robot. The system has been developed by python and embedded C programming language. The robotic system with GPS controlled feature enables to move according to user's instruction autonomously and collects sensor data from targeted locations. An Android app has been developed for the user- friendly interface [10].

III. SYSTEM OVERVIEW

Environment Monitoring is collection of data and information on Environmental Parametres. Solving environmental pollution and to evaluating the health of natural resources through monitoring. For monitoring manually in the extremely polluted region there is some health risk. For avoiding such health risk a robotic vehicle is developed which has data acquisition, communication and processing are crucial in revolutionizing monitoring and protection. So that the monitoring can be done without human intervention.

In Environmental Monitoring the system uses SIM7600E-H 4G communication module with inbuilt GNSS is used.SIM7600E-H 4G is used to control the robot over a long distance. Also in this type of monitoring different types of sensors are used that is MQ135 and MQ7 is used as gas sensors. It can detect a wide range of gases such as NH3, NOX, alcohol, benzene, smoke and CO2. Another type of sensor is Adafruit BME280 sensor which can sense temperature, barometric pressure and humidity. SI1145 is a new sensor which is used to sense visible and IR light from the sun. In this section communication with sensors are established by Raspberry Pi. Here more sensors are used and for their connection GPIO triplicator is used. We use Arduino to control the motor drive because Raspberry Pi does not meet the power requirement to run the driver. So the Raspberry Pi give commands to Aurduino for navigation. The battery is recharged using a commercially available Si solar cell module through ADP5092 PMU. If in case, the vehicle need to be operated continuously without giving time to recharge through solar cell, the battery can be replaced with the fully charged one. All collected data is sent to IoT platform in order to accessed by the user from a wireless connection.

IV. SYSTEM ARCHITECTURE

Figure 1 shows the proposed architecture of the environmental sensing vehicle based on the ARM processor. The architecture is categorized into environmental sensing and control system and navigation system.

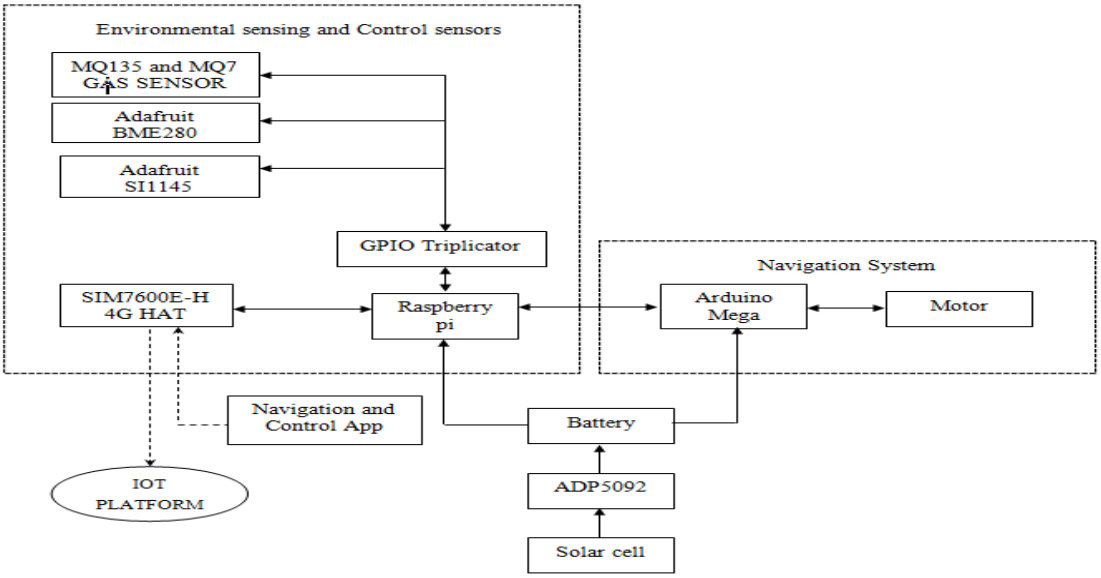

Fig -1: The block diagram of robotic system design

Environmental sensing and control system for Raspberry Pi

The Raspberry Pi is equipped with sensors detailed in Table 1 to monitor the environmental conditions. As the GPIO pins available in default with raspberry pi is limited, we propose to extend it with the GPIO triplicator. The necessary communication

to upload the environmental data to the IOT cloud storage platform and to receive the navigation commands from the mobile application is established by SIM7600E- 4G module.

Navigation system

As the power requirement of the motor drive is high, the navigation system is dedicatedly designed using Arduino development board. The instructions sent from mobile application is processed by the raspberry pi first, and it is given as commands to the Arduino to run the motor drive circuit.

V. HARDWARE COMPONENTS

Arduino Mega

Arduino Mega gives the flexibility of working with more memory space and processing power that allows to work with a number of sensors at once. The Arduino Mega is a microcontroller board based on the ATmega2560 containing 54 digital input/output pins, 16 analog inputs, 4 UARTs (hardware serial ports). ATmega2560 is our choice as it is an easy option for use in prototyping with ease in robotics.

Raspberry Pi

A Raspberry Pi 3B is an ARM-based single board computer. It has Broadcom BCM2837 64bit ARM Cortex- A53 Quad Core Processor SoC running at 1.2GHz and 1GB RAM. It has 40 GPIO pins used for the general purpose.

SIM7600E-H 4G HAT

The SIM7600E-H 4G HAT is a 4G/3G/2G communication module with inbuilt GNSS, which supports LTE CAT4 up to 150Mbps for downlink data transfer. It is pretty low power consumption.

GPIO Triplicator

Stands for "General Purpose Input/Output." GPIO is a type of pin found on an integrated circuit. It's a standard interface used to connect microcontrollers to other electronic devices. For example, it can be used with sensors, displays, and System-on-Chip modules. To use GPIO Triplicator , because we connecting more sensors. Hence we need more GPIO pins.

Navigation and Control Hardware

To use Arduino Mega to control the Motor drive because Raspberry Pi does not meet the power requirement to run the motor. So the Raspberry Pi to give commands to Arduino for navigation.

ThingsSpeak

Open-source IoT platform Thing Speak is used to collect and store sensor data in the cloud and helps in the development of IoT application [11]. The Raspberry Pi connected with SIM7600E-H-4G HAT module that sends the data value from the sensors to the IoT platform. Thing Speak performs real-time visualization by using MATLAB software. The data can also be extracted directly from the platform, and anyone can process and visualize the information using any statistical software. Smart phone or PC to control the navigation and we can use IoT cloud storage to store the environmental data.

VI. SENSORS

MQ135 Air Quality Sensor

Fig -2: Air Quality Sensor

Air quality sensor is used for detecting the presence of gases, including NH3, NOx, alcohol, benzene, smoke and CO2. It is most widely used in office or factory. MQ135 is gas sensor and it has high sensitivity to Ammonia, Sulfide and Benzene steam, also sensitive to smoke and other harmful gases. An alcohol sensor is used to detects the attentiveness of alcohol gas in the air and an analog voltage is an output reading. For temperatures ranging from -10° to 50° C the sensor will activate and power supply is less than 150 Ma to 5V. The sensing range is from 0.04 mg/L to 4 mg/L and is suitable for breathalyzers. **Figure 2** shows the MQ135 Air Quality Sensor.

MQ-7 Gas Sensor

Fig -3: Gas Sensor

For detecting the presence of Carbon Monoxide (CO) in air MQ-7 sensor is used. This sensor can detect CO concentrations in anywhere, that is ,20 to 2000ppm.It has a high sensitivity and fast response time. The sensor's output is an analog resistance. **Figure 3** shows the MQ-7 Gas Sensor.

Adafruit BME280 Sensor

Fig -4: BME280 sensor

Adafruit BME280 sensor, an environmental sensor with temperature, barometric pressure and humidity. This sensor is great for all types of weather or environmental sensing and can even be used in both I2C and SPI. Sensor reads the barometric pressure, humidity and temperature and displays it on the console. **Figure 4** shows the Adafruit BME280 sensor.

Adafruit SI1145 sensor

Fig -5: SI1145 Sensor

The SI1145 is a new sensor with a calibrated light sensing algorithm that can calculate UV Index. Also it senses on visible & IR light from the sun. It is a digital sensor that works over I2C so just about any microcontroller can use it. The sensor also has individual visible and IR sensing elements so it can measure any kind of light. If precision is needed Lux measurement check out the TSL2561.The IR LED is connected to the LED pin and use the basic proximity sensor capability that is in the SI1145 as well. **Figure 5** shows the Adafruit SI1145 sensor.

VII. PROPOSED SYSTEM

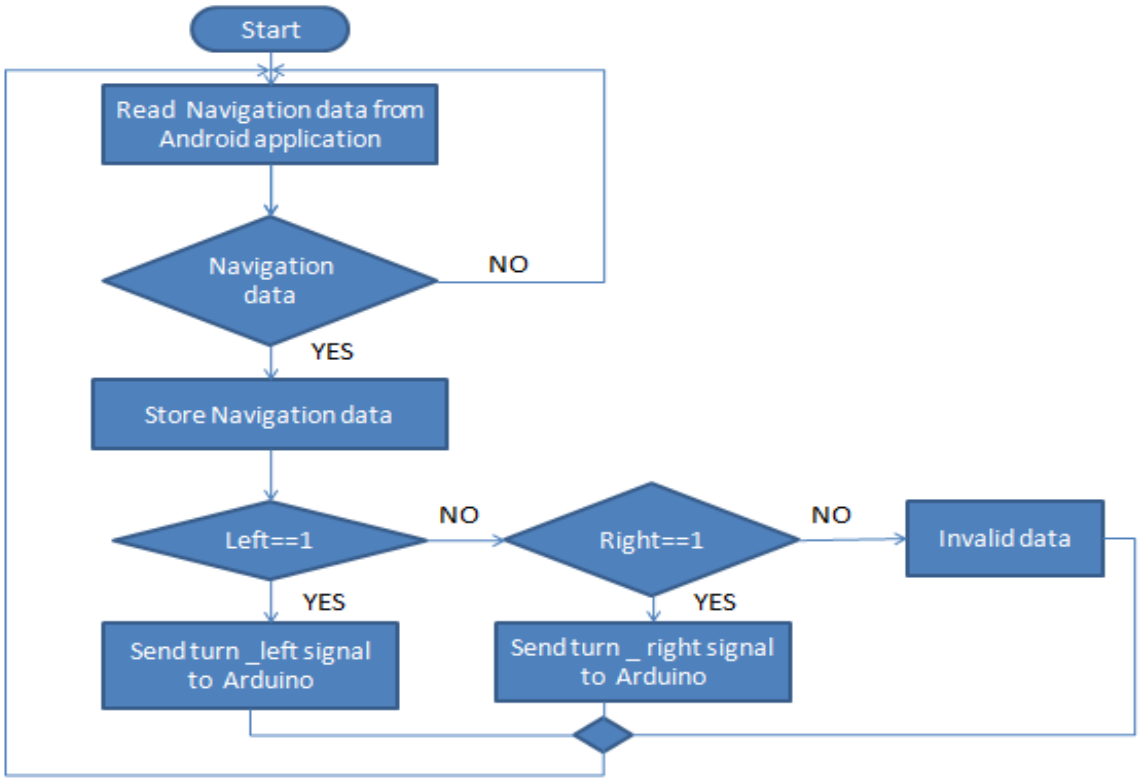

Fig-6: Flow Chart of Navigation System-Raspberry Pi

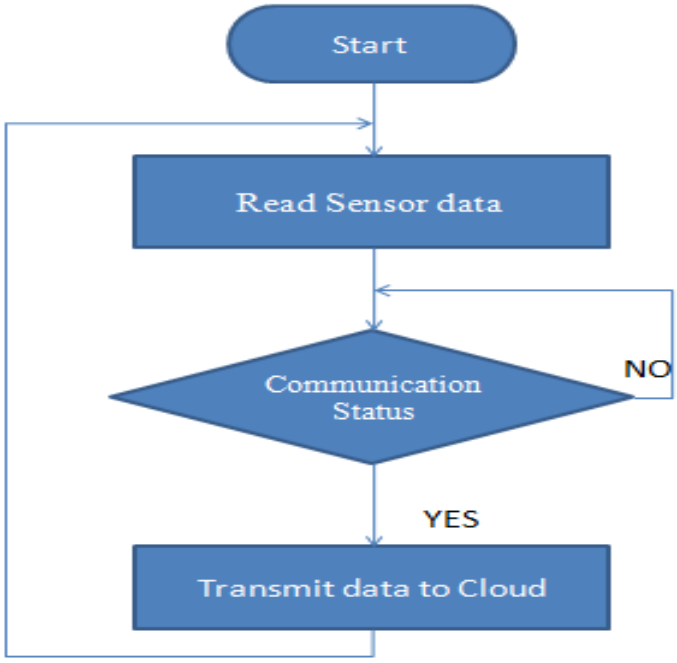

Fig-7: Flow Chart of Environment Sensing-Raspberry Pi

VIII. **CONCLUSION**

In this system, the design of 3G GSM controlled robotic vehicle for monitoring environmental parameters which is based on IOT is accomplished. The robotic system which can monitor environmental parameters and to measure the quality of air is compact and cost-effective. Here 3G GSM allows the user to control the robot at a longer distance efficiently without any delay. Also navigation is controlled by smartphone and for storing environment data IOT cloud storage is used. Environmental sensors which is upgraded to measure additional parameters such as atmospheric pressure and light(IR,UV etc).An energy harvester included in the design, that is by solar cell battery will be charged via ADP5092.

The key advantages of the system is it is cost effective and the cost is less than 70 USD. After getting instruction from the user the movement is autonomous. The future benefits such as solar cell battery charging, Long distance controlling and additional environmental sensing all can be occupied. At last the system is more efficient to protect human from direct exposure to the environment parameters which can cause health risks.

REFERENCES

[1] Liu, F.H.: Research and Implementation of WiFi Wireless Communication Terminal Based on ARM. Wuhan University of Science and Technology, China (2010).

[2] M. Trincavelli, M. Reggente, S. Coradeschi, A. Loutfi, H. Ishida and A J. Lilienthal, "Towards environmental monitoring with mobile robots," 2008 IEEE/RSJ International Conference on Intelligent Robots and Systems, Nice, 2008, pp. 2210-2215.

[3] M. Dunbabin and L. Marques, "Robotics for Environmental Monitoring [From the Guest Editors]," in IEEE Robotics & Automation Magazine, vol. 19, no. 1, pp. 20-23, March 2012.

[4] [4] G. Mois, T. Sanislav and S. C. Folea, "A Cyber-Physical System for Environmental Monitoring," in IEEE Transactions on Instrumentation and Measurement, vol. 65, no. 6, pp. 1463-1471, June 2016.

[5] R. Shete and S. Agrawal, "IoT based urban climate monitoring using sSignal Processing (ICCSP), Melmaruvathur, 2016, pp. 2008-2012.

[6] B. Jiang and C. F. Huacón, "Cloud-based smart device for environment monitoring," 2017 IEEE Conference on Technologies for Sustainability (SusTech), Phoenix, AZ, 2017, pp. 1-6.

[7] S. Pasha, "ThingSpeak based sensing and monitoring system", International Journal of New Technology and Research, Vol. 2, No. 6, pp. 19-23, 2016

[8] S. D. Shewale, S. N. Gaikwad, "An IoT based real-time weather monitoring system using Raspberry Pi", International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering", Vol. 6, No. 6, pp. 4242-4249, 2017

[9] S. Ferdoush, X. Li, "Wireless sensor network system design using Raspberry Pi and Arduino for environmental monitoring application", Procedia Computer Science, Vol. 34, pp. 103-110, 2014

[10] The MathWorks, Inc,"Understand Your Things" Internet:https://thingspeak.com/

[11] A. Tapashetti, D. Vegiraju and T. Ogunfunmi, "IoT-enabled air quality monitoring device: A low cost smart health solution," 2016 IEEE Global Humanitarian Technology Conference (GHTC), Seattle, WA, 2016, pp. 682-685.