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The Design and Implementation of Environment Monitoring Robotic System Based on IOT and Raspberry Pi 3B+ Model

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ABSTRACT: Robot systems are merger being utilized as elementary data gathering tools by scientists, allowing new aspects and a preeminent understanding of the earth and its environmental processes. Deep oceans, harmful algal blooms, climate variables and even remote volcanoes are studied by using today's robots. This paper analogizes and discusses the advancements and applications of mining robotic system developed for environmental monitoring. To design a robot that is to monitor environmental parameters such as temperature, humidity, air quality and harmful gas concentration. The robot has GPS co-ordinates and it can store data on the THINGSPEAK, IOT platform. The whole system is realized using a cost effective embedded system called Raspberry pi 3 B+ model which communicates through a wireless network to the IOT platform. By which data are stored, processed and can be accessed using a computer or any smart devices form anywhere through the IP address. The system can update sensors, navigation and live stream date to IOT IP server every 15 second.

KEYWORDS: ARM and Embedded system, Raspberry pi, THINGSPEAK, IOT, Air quality, Gas Sensor, GPS, Android App, Remote Monitoring.

I. INTRODUCATION

Environment monitoring is that the gathering of knowledge and data on environmental parameters. Monitoring and checking the health of our natural resources is additionally essential for effective environmental planning, policymaking and solving environmental pollution. For the extremely polluted region, it carries the health risk for monitoring manually. To avoid these risks, remote monitoring techniques together with a robotic system that has intelligent data achievement, communication and processing are crucial in revolutionizing monitoring and security protection. For remote monitoring, developing a system are going to be an efficient solution so the monitoring is kept away from any human intervention. Recently, robotic systems are utilized as data-gathering tools by scientists for a greater assimilates of environmental processes. Robots also are being designed to explore areas with harmful gases, monitor climate, and to check a few remote place that's quite risky for the human. Keeping the above statement within the forefront, the new decided wireless sensor is getting integrated on one board, intended towards the expansion of this method. The Raspberry Pi 3 model B+ includes Broadcom BCM2837 64-bit ARMv8 Quad-Core Processor powered Single Board. It also has enough pins for GPIO and serial communication pin that may be connected to the amount of sensors. Those entire benefits make Raspberry pi 3 model B+ the foremost effective selection for completing the system. In order to deploy a scalable and remote monitoring system, an efficient platform that permits users to observe 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 information monitors and accesses from anywhere using mobile phones or PC with Internet access. The implementation has sensors for air quality, CO, CO2, and temperature and humidity to observe the environment around. The Raspberry Pi has been wont to interact with the IOT platform and sensors. The Raspberry PI is employed for control and navigation of the robot. The system has been developed by python and embedded C artificial language. The robotic system with GPS controlled feature enables to maneuver consistent with user's instruction autonomously and collects sensor data from targeted locations. An Android app has been developed for the user- friendly interface. All collected data is shipped to the THINGSPEAK, IOT platform so as to be accessed by the user from a wireless connection. Real-time cloud graphical visualization is performed to research the collected data. This multipurpose robotic system is capable of remote monitoring with none human intervention and keeping away environmental hazard risks.

Environmental monitoring defines the method and enterprise that require requiring place to characterizer and monitoring quality of the environment. All the monitoring approach and programs have reasons and justification which is commonly designed to make the present status of the environment or to determine trends in environmental parameters. the development of a program must therefore have relevance the ultimate use of the information before monitoring starts. Function and benefits of environmental monitoring is to grasp whether quality of environment is getting improved or worse. The foremost extensive purpose or advantage of environmental monitoring is to watch an analyzer trends and patterns of presence of air pollutions within the atmosphere. The pair of pollution save energy and supply an overall living environment enhancement. Using the compounds like Raspberry Pi 3B+ model, Camera GPS and a few sensors with the robot is to watch and detect automatically around a robot's environment. Raspberry Pi controller receive the information from camera, GPS and sensors that's broadcast to the raspberry through the wireless IOT and also it can control of wheel with relation to the user command from website. Raspberry Pi connected to the wired website connected or interfaced through the WIFI for user can entrance the robot anywhere from the webpage. This project is utilized in housing protection, sewage cleaning, mining protection and nuclear thermal industry.

II. RELATED WORK

Existing environmental monitoring systems discussed here in this section, with a focus on environmental sensors, robotic systems, as well as IOT are also reviewed to clarify the essence of this work.

A. *ENVIROBOT:*

Bio-inspired environmental monitoring platform autonomous marine vehicles are becoming essential tools in aquatic environmental monitoring systems, and can be used for instance for data acquisition, remote sensing, and mapping of the spatial extent of pollutant spills

B. *IOT-MOBAIR:*

Global Air Pollution monitoring platform

C. *ECOCHIP:*

Wireless multi-sensor platform for comprehensive environmental monitoring which can monitor the electro-chemical impendence in the environment atmosphere.

III. MOTIVATION

Some of the problem faces in India are:

- India records 377 mine deaths in past three years was reported by Hindu newspaper.
- The Safai Karamchari Andolan, a group campaigning to make sewage cleaning jobs safer, estimates that about 1,850 people have died in the last decade while cleaning sewers.
- The National Commission for Safai Karamacharis estimates that one person dies every five days in the country while cleaning sewers or septic tanks.
- On August 28, was an explosion in a chemical factory in Maharashtra's Dhule district in which 13 were killed and 72 injured.
- On October 9, was an explosion in Tamilnadu 11 were killed reason is that cylinder was found intact. Gas had leaked from the cylinder the house was filled with a smell.

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The discussion mentioned above merely lists a few of the health rises. So this project consists of remote monitoring of environmental conditions, mainly using wireless sensing methods, GPS, robotics, IOT-based technologies. In order to tackle the problem of remote environment monitoring with avoiding health risks.

IV. SYSTEM ARCHITECTURE

The proposed robotic system has designed incorporating the embedded hardware, software, and IOT components. The system architecture is shown in fig. 1 which illustrates the block diagram of the IOT and embedded robotic System. The whole robotic system has eight parts:

1. Environment Monitoring System: This system is responsible for collecting data from the sensor and uploading collected data to the IOT platform.
2. Raspberry PI camera is used for the live stream such that it can be operator from anywhere in the world by just using the WIFI or IP address connection
3. Navigation and Control System: The primary function of this system is to navigate and control the movement of the robotic system according to the instruction from the app.
4. The environment monitoring system utilizes the Raspberry Pi to communicate with three sensors such as the DHT11, the MQ135, and MQ7 Gas sensor.
5. The robot is part of the Internet of Things because it requires network connectivity through a GPRS module connected with raspberry pi it uses sensors to collect environmental parameters data, so the system needs minimum human intervention.
6. The robot navigation and control system consists of a GPS and Compass module, DC motor and robot chassis. L293D motor driver has been used with Raspberry PI to control the DC motor.
7. The Raspberry Pi collects sensor data from targeted locations and uploads data into the IOT platform which can be accessed directly by the navigation system utilizes the Raspberry PI to communicate with the GPS module and the compass to navigate and move in a fixed path from the initial location to the destination.
8. An App has been developed to give the instruction which communicates through the WIFI and IP address connection.

The data monitors and accesses from anywhere using mobile phones or PC with Internet access.

The implementation has sensors for air quality, CO, CO_2, and temperature and humidity to monitor the environment around. The Raspberry Pi has been used to interact with the IOT platform and sensors. The Raspberry PI 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. All collected data is sent to the THINGSPEAK and IOT.

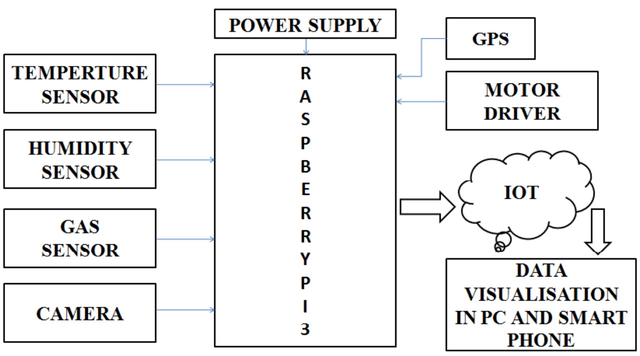

Figure1: Block diagram of proposed system

V. HARDWARE COMPONENTS

A. RASPBERRY PI 3B:

A Raspberry Pi 3B (RP) 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. Additionally, it adds wireless LAN and Bluetooth connectivity making it the ideal solution for powerfully connected designs

.

B. ENVIRONMENT SENSING:

The robotic system uses sensors such as the DHT11 Temperature and Humidity Sensor, MQ-7 Carbon-mono-oxide Gas Sensor and MQ135 Air Quality Sensor. The system also can monitor environmental parameters such as CO2 and smoke as well. The DHT11 is a digital temperature and humidity sensor. It uses a capacitive humidity sensor and a thermistor to measure the surrounding air and spits out a digital signal on the data pin [10]. The air quality sensor is the MQ-135 sensor for detecting toxic gases that are present in the air. Being a very dangerous gas Carbon monoxide (CO) is odorless, colorless, so it cannot be smelt, seen, or tasted which makes it difficult to detect. MQ7 Carbon Monoxide (CO) gas sensor detects the concentrations of CO in the air and outputs its reading as an analog voltage anywhere from 20 to 2000ppm. This sensor has a high sensitivity and fast response time. There is a screw potentiometer that enables manual adjustments to the output gain of the sensor. The ADS1015 is used to convert analog data to digital data received from both sensors.

C. NAVIGATION AND CONTROL HARDWARE:

For navigation, the system requires the GPS module U- box NEO-6M, and the compass HMC5883L with Raspberry PI 3 model B+. Global Positioning System (GPS) is a satellite-based navigation system that provides critical positioning capabilities to the robot. Along the way, The HC-SR04 ultrasonic distance sensor is used for obstacle detection. L293D motor shield controls the robot's movement according to its navigation. The HMC5883L is a triple axis magnetometer that uses the basic principle behind electromagnets to sense magnetic north pole. This compact sensor uses I2C to communicate. The L293D, A motor driver is an integrated circuit chip which is usually used to control motors in robots.

D. THINGSPEAK:

Open-source IOT platform THINGSPEAK is used to collect and store sensor data in the cloud and helps in the development of IOT application. Read and write API keys were generated on THINGSPEAK. The Raspberry Pi connected with Internet-enabled GPRS module that sends the data value from the sensors to the IOT platform. THINGSPEAK performs real-time visualization by using webpage or in online. The data can also be extracted directly from the platform, and anyone can process and visualize the information using any statistical software.

E. RASPBERRY PI CAMERA:

The Raspberry Pi Camera Board plugs directly into the CSI connector on the Raspberry Pi. It's able to deliver a crystal clear 5MP resolution image or 1080p HD video recording at 30fps! Latest Version 1.3! Custom designed and manufactured by the Raspberry Pi Foundation in the UK, the Raspberry Pi Camera Board features a 5MP (2592*1944 pixels) Omni vision 5647 sensor in a fixed focus module. The module attaches to Raspberry Pi, by way of a 15 Pin Ribbon Cable, to the dedicated 15-pin MIPI Camera Serial Interface (CSI), which was designed especially for interfacing to cameras. The CSI bus is capable of extremely high data rates, and it exclusively carries pixel data to the BCM2835 processor. The board itself is tiny, at around 25mm x 20mm x 9mm, and weighs just over 3g, making it perfect for mobile or other applications where size and weight are important. The sensor itself has a native resolution of 5 megapixels, and has a fixed focus lens onboard.

F. NETWORK SYSTEM HARDWARE:

The system uses an HC-06 Bluetooth module or WIFI for building personal area networks (PANs). It has been connected to Raspberry PI to communicate with the App. SIM800L GPRS module allows raspberry pi to connect

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with wide area network (WAN) using a corresponding pin connection. The technique used for communication with the peripheral device in this project is I2C (Inter-Integrated Circuit).

VI. HARDWARE DESIGN

The robotic system is built by using mechanical and electrical components, and it is of the wheeled type. The Raspberry PI 3 model B+ serves as the central part for the navigation and control system. GPS module is mounted on the Raspberry PI to tag the GPS coordinates of the robot's position. The robot is equipped with an ultrasonic sensor to measure the distance between the robot and an obstacle. The system moves in a fixed path according to the app's instructions. Fig. 2 shows the circuit diagram of the whole system. Two DC motors are used to control the movement of the robot. HC-06, HMC588L, and Neo 6M GPS Modules are connected to the Raspberry PI. Note the HMC588L compass should be placed away from any ferromagnetic element; otherwise, it may misdirect the robot. For this reason, the compass has been placed in a surface made of plastics and wood that is away from the main body which is made of a ferromagnetic element. This ensures the compass to get the accurate direction of the robot. The GPS module searches for at least four satellite and gets a GPS location.

After getting a GPS location, it follows the program flow of the embedded python code and moves to its destination GPS location that will be given to the robot by App. For all modules VCC is 5V, and the GND is connected to the GND on Raspberry PI board. Rest of the pin connections are followed from figure 1. In the design of the environment monitoring system, the most critical part is to sense analog value from the environment. The Raspberry Pi supports I2C serial communication and only digital input. To solve this issue, the ADS1015 ADC has been utilized which supports I2C communication. The GPRS module is attached with Raspberry Pi ensuring connection with WAN. Using API key provided by the THINGSPEAK, the Raspberry Pi follow the program flow of fig. 3 and starts uploading sensor data using internet connection. The GPRS module requires a SIM card for internet service. The sensors MQ7, MQ135, DHT11, should be connected through ADS1015 with Raspberry PI. For all modules VCC is 5V, and the GND is connected to the GND on board. Rest of the pin connections followed form the figure 2.

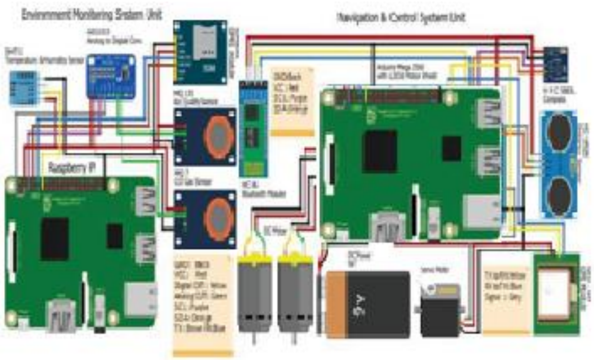

Figure 2: Circuit Diagram of proposal system.

VII. SOFTWARE DESIGN AND PROGRAMMING

A. Android App Development Tools:

MIT AppInventor is a visual, block-based development environment which does not require any prior programming knowledge. We choose MIT AppInventor as the android application development tool. MIT and Google jointly develop AppInventor, and it has gained popularity as a learning tool and a way by which students can practice creative innovations.

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B. Embedding Code in Raspberry Pi:

For the realization of the environment monitoring system in software, the python code is used according to the program flow of fig. 3 to program raspberry pi. The primary function of the code is to collect sensor data and upload the data to the IOT platform using API keys. At first, the system initializes libraries and modules of that are needed to run some built-in function. At the same time, we stored the API key as a variable. Then I2C communication has been enabled so that it can communicate with ADC pins to get analog value from the sensor. After that, we have defined one function to read ADC value. The ADC pin will read sensor data and store that value in a variable. Another function has been defined to upload sensor data using the API key variable to the IOT platform. Finally, both functions are called in a loop which repeats calling the function if the internet is available.

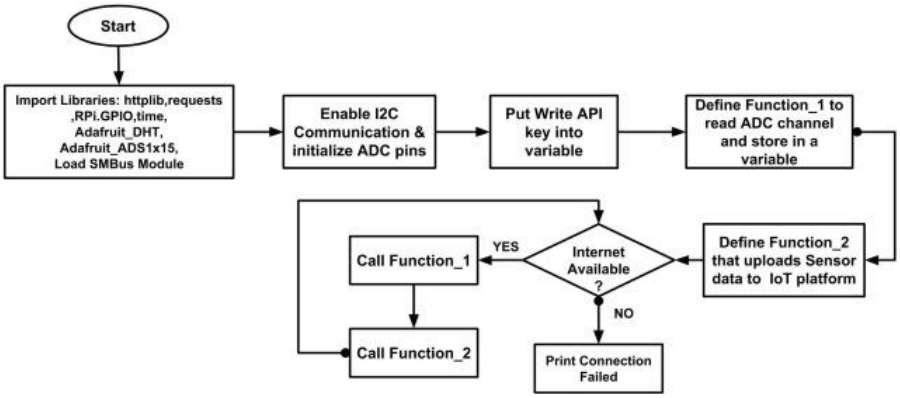

Figure 3: Program flow of the sensors data collection and storage to the IOT platform.

The Raspberry PI is programmed with embedded C language in an integrated development environment (IDE). In the program flow of the embedded python code is given. At first, the system initializes libraries and a module of that is needed to run some built-in function. At the same time, the system starts serial communications and I2C bus with Bluetooth, Compass and GPS module. At first, the GPS module starts looking for and acquires at least four satellites to get a GPS coordinate. After receiving the current GPS location, the system gets compass heading of the robot. After that, the user can set the GPS coordinate as a waypoint that the robot will follow to move. The waypoints are stored in an array so that the program can use them to provide the robot with five locations of which a waypoint array declares, and a path is planned according to a series of waypoints. The app can perform all of these steps. Unless the stop signal is received the robot continues to update compass heading and GPS information as well as moving towards the destination. During this, all these procedures repeat until the final waypoint obtains. Finally, after reaching the final waypoint, the robot completes its ride. Along with all these things, there is also an option to clear the previous set waypoints to reset the robot and start the whole operation once again.

VIII. RESULT

Figure 5 shows the entire prototyping of IOT and Raspberry PI based GPS controlled environment monitoring robot and Navigation and Control app. Figure 6 show the whole system control. Figure7show live stream output. Figure 8 show the logical output in the android application the prototype can work effectively in foreign places to gather data, alone or in teams. The proposed system is sort of cost-effective compared with other existing methods that need more number of hardware accessories. The robot is capable of collecting and uploading environmental data to the THINGSPEAK, IOT platform server efficiently. The sphere updating time at channel takes a minimum of 15 seconds. The sensor data stored within the platform are often used for visualization and analysis of the environmental parameters. Figure 9 is additionally showing the monoxide and dioxide gas sensor data in PPM, temperature sensor data and humidity sensor data in percent ratio (%RH), respectively in the THINGSPEAK website and in the android application for better and easy use of the robotic system.

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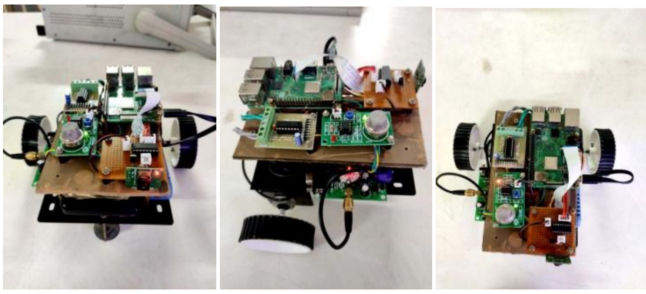

Figure 5: whole system structure.

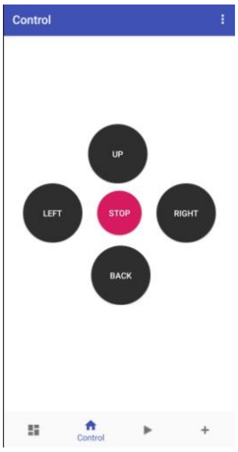

Figure 6: Whole system controle

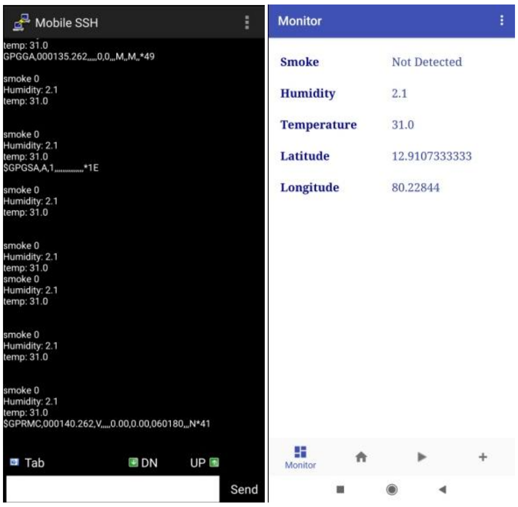

Figure 7: logical output of the system

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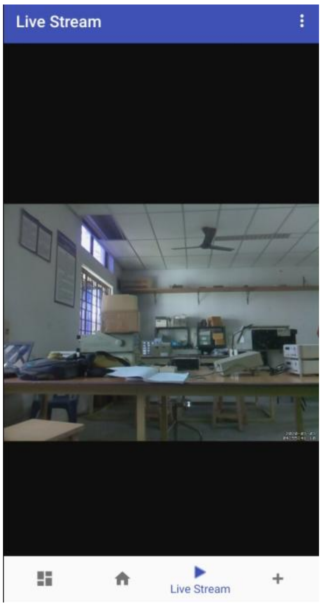

Figure 8: Live streaming using Raspberry PI

Figure 9: Real-time graphical visualization of the environmental parameter

IX. CONCULSION

In this present work, design, and implementation of a GPS controlled robot for environmental parameters monitoring supported IOT and Raspberry PI 3 model are done by simply and price effectively. The developed Raspberry PI-based embedded system with the IOT platform can monitor the environmental parameters, and also the measurement of air quality is compact and cost-effective. The results obtained are found to be useful for monitoring real-time environmental parameters conditions around the world. The developed App allows the user to manage and navigate the robot easily. The GPS controlled feature allows it to travel autonomously to the remote places and submits the collected data to the IOT server likewise as displays it on the online for a high-level data analysis and processing.

Graphical visualization that the evidence shows that the robotic system works efficiently and more over cost effective. Moreover, the key advantages of the system are the intuitive user interfaces within the App and Autonomous movement after getting instruction from the user. Also, the system is cost-effective, and also the costs are but 10,000 rupees. It updates sensor data to IOT server in every 15 seconds. Secured data in IOT platform and will be accessed from anywhere of the planet. Future work includes several features including alternative energy, advanced

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communication solutions for rural areas. The systems are often modified to detect radiation and even different sorts of harmful gas autonomously to avoid human health risks. Also, the look method can dynamic.

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