AI & IOT enabled Global Remote Sensing System for Sustainable Living and Smart Cities

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ABSTRACT

In recent years, people are getting more conscious of the environment they are living in. This consciousness is driving the need to develop a reliable environmental monitoring system. An environmental and Air quality monitoring system also has industrial applications. In mining or in heavy industry, there is a possibility of air contamination by harmful gases. In such hazardous situations, an environmental monitoring system can potentially save the life of the workers. In such large-scale sensor deployment, there are data collection, data management, connection, and power consumption issues. IoT technology is specifically suited for this sort of need. This paper presents an IOT-based framework that effectively monitors the change in an environment using sensors, micro-controller, and IOT-based technology. Users can monitor temperature, and humidity, and detect the presence of harmful gases both in the indoor and outdoor environment using the proposed module. The data is stored in the web server and the user can access the data anywhere in the world through an internet connection. In the proposed work a web application is developed to provide vital information to the user. The user can also set up a notification for critical changes in the sensor data. In comparison to other closely related systems, the proposed system is a low-cost one, accurate and user-friendly. It is also cloud-based and has easy monitoring and data visualization modules. The system has been evaluated in different stages. After testing all the functions in different conditions, it shows a high degree of accuracy and reliability.

Keywords - IOT, GPS module, Smart environmental sensors, Bigdata, Machine learning, tensor-flow, Aamazon s3, etc.

I. INTRODUCTION

The Internet of Things (IoT) technology is utilized to transmit the measured pollutant concentrations to an online dashboard to visualize and post-process the data. Raspberry PI is a versatile SCB that can be integrated with a wireless sensor network (WSN) to determine Temperature, Pressure, Humidity, and Humidity. Attaching multiple gas sensors to a Raspberry Pi 4B board the measured data can be visualized in real-time and also extracted remotely using a local network by the end-user. The aim of this project is to present a comprehensive indoor air quality monitoring system using a low-cost Raspberry Pi-based air quality sensor module. The proposed system measures environmental parameters such as temperature, Relative Humidity, $PM_{2.5}$, PM_{10}, O_2, CO_2, CO, O_3, Noise, Radiation level, and TVOC in real time to determine air quality[2]. The remainder of this paper is structured as follows. It describes the GRS system with its constituent sensors and the GPS module was connected through the UART port and Grove pi Hat is used for connecting with multiple I2C devices on Raspberry PI. The monitoring methods and different data analysis techniques employed are also detailed. Water and air quality are essential to maintain the equilibrium between human development and a healthy environment.[5] It is also important to notice that by means of looking for more efficient production in factories both pollution and consumption of natural resources can be decreased. Processes, such as boiling, drying, binding, and so forth, are being carried out by almost every kind of current factory.[12]. Indoor air pollution has become a serious issue affecting public health. An indoor air quality monitoring system helps in the detection and improvement of indoor air quality. The monitoring systems presently available are very expensive. [11]. Effective change management is one of the most challenging issues in the world. Government, semi-government, and public organizations are preparing to face this challenge in terms of social and environmental fronts and trying to make the world a better place to live for us. In order to cope up with the dynamism of changing reality, various smart systems have been developed, including household automation [1-2], traffic and accident monitoring [4-5], smart city solution [6-7], automated irrigation [8], smart grid [9], real-life problem-solving using robotics [10- 12], wireless sensor network systems [13-16], web-based service [17-20], etc. Air quality is a major concern nowadays that requires monitoring of several parameters responsible for this problem. As per the systems mentioned in [1-7], a feasible technical solution to monitor environmental conditions and changes is quite important. The Internet of Things (IoT) offers a highly effective way of monitoring parameters related to air quality [21-23]

II. Related Works: Various attempts and research were made to overcome the Environment Global warming issue and still it undergoes.

1. Design AI & IOT-based GRS System:
The first step towards connecting with multiple sensors on a single system with the integration of wireless sensor networks Hence this system has provided user and eco friendly

2. Data Analytics:
In the second level of the system continuously try all the possible combinations of sensor values populating within seconds of time to store the logs in understandable formats (CSV, JSON, etc.) for present and future reference on global warming issues.

3. Android deployment:
As an end system for user experience simplification, A mobile app has been provided with Custom screens, an alert mechanism, and Analytical reports for better tracking of the GRS system.

III. Hardware Platform
The hardware part mainly consists of a small capacitive DSI touch display and a Raspberry Pi 4B Kit, Seed Grove studio pi hat, GPS module, seeedgroveBme680, Oxygen, CO2, SGP30, Air Quality, Radiation levels, Noise, Industrial sensors, pm 2.5 Air Quality, CO, etc. which is being discussed along with their specific functions.

1. Raspberry Pi Kit: The Raspberry Pi is a series of small single-board computers developed by the United Kingdom by the Raspberry Foundation to promote the teaching of computer science in schools and developing countries. Peripherals (including keyboard, mice, and cases) are not included with the Raspberry Pi. It is bundled with onboard Wi-Fi, Bluetooth, and USB boot capabilities. It has a Broadcom System-On-Chip, which includes an ARM-compatible central processing unit (CPU) and an on-chip graphics processing unit (GPU, a video core). CPU speed ranges from 700 to 1.2GHz for Pi 4 and onboard memory ranges from 1GB to 8GB. Secure Digital (SD) cards are used to store the operating system and program memory either in SDHC or microSD sizes. Lower-level output is produced by a number of GPIO pins that support common protocols. It supports Raspbian, a Debian-based Linux distribution for download as well as the third-party Ubuntu, Windows 10 IT Core, RISC OS, and centralized media center distributions. It promotes Python and Scratch as the main programming languages with support for many other languages. The Raspberry Pi 4 supports 8GB RAM.

2. Seed Grove pi hat:
Today, the grove series of sensors, actuators, and displays have grown into a large family. More and more grove modules will join the Grove ecosystem in the future. We see the Grove helps makers, engineers, teachers, students, and even artists to build, to make, to create...We always feel it is our responsibility to make the Grove module compatible with more platforms. Now we bring you the Grove Base Hat for Raspberry Pi and Grove Base Hat for Raspberry Pi Zero, in another word, we bring the Raspberry Pi the Grove System.
The Grove Base Hat for Raspberry Pi provides a Digital/Analog/I2C/PWM/UART port to meet all your needs. With the help of a built-in MCU, a 12-bit 8-channel ADC is also available for Raspberry Pi.

3. Capacitive DSI Display interface:
4.3-inch Capacitive Touch Display was for Raspberry Pi Series and CM3/3+ 800×480 IPS Wide Angle MIPI DSI Interface Up to 5-Points Touch Driver Free. it Supports Pi 4B/3B+/3A+/3B/2B/B+/A+, CM3/3+(CM3/3+ requires extra adapter board)
And it Supports Raspbian, 5-point touch, driver free; Supports Ubuntu / Kali / WIN10 IoT, single point touch, driver free; Supports Retro pie, driver free Capacitive touch, up to 5-point touch (depending on the operating system)

4. GPS module:
Here I will use Raspberry Pi 4 B+, but You can also use other variants like Raspberry Pi Zero, Raspberry Pi 4, etc. I am using Neo 6M as a GPS module because it’s quite cheap and also very much accurate. So, we need the VCC of Neo 6M to be connected with 5v of Raspberry pi, GND of Neo 6M with GND of Raspberry pi and TX of Neo 6M with RX of Raspberry Pi so that the GPS module can

5. Seed Grove sensors:

Grove is a system of some nicely packaged sensors designed to be used with Seed Studio's Grove shields for Raspberry pi 4b. Since many of them are analog sensors like Air Quality, Oxygen, Noise levels, etc. digital sensors you'd need an external ADC for the Raspberry Pi. Alternatively, some of the I2C sensors are connected as listed SGP30, CO2, and UV sensors. What really makes it easy to connect Grove Connectors to the Raspberry Pi, is to add a Grove shield to the Raspberry Pi, like the Pi2Grover connector.

IV. Methodology

In this model, our aim is to propose a smart city GRS system for people's in figure 1 below.

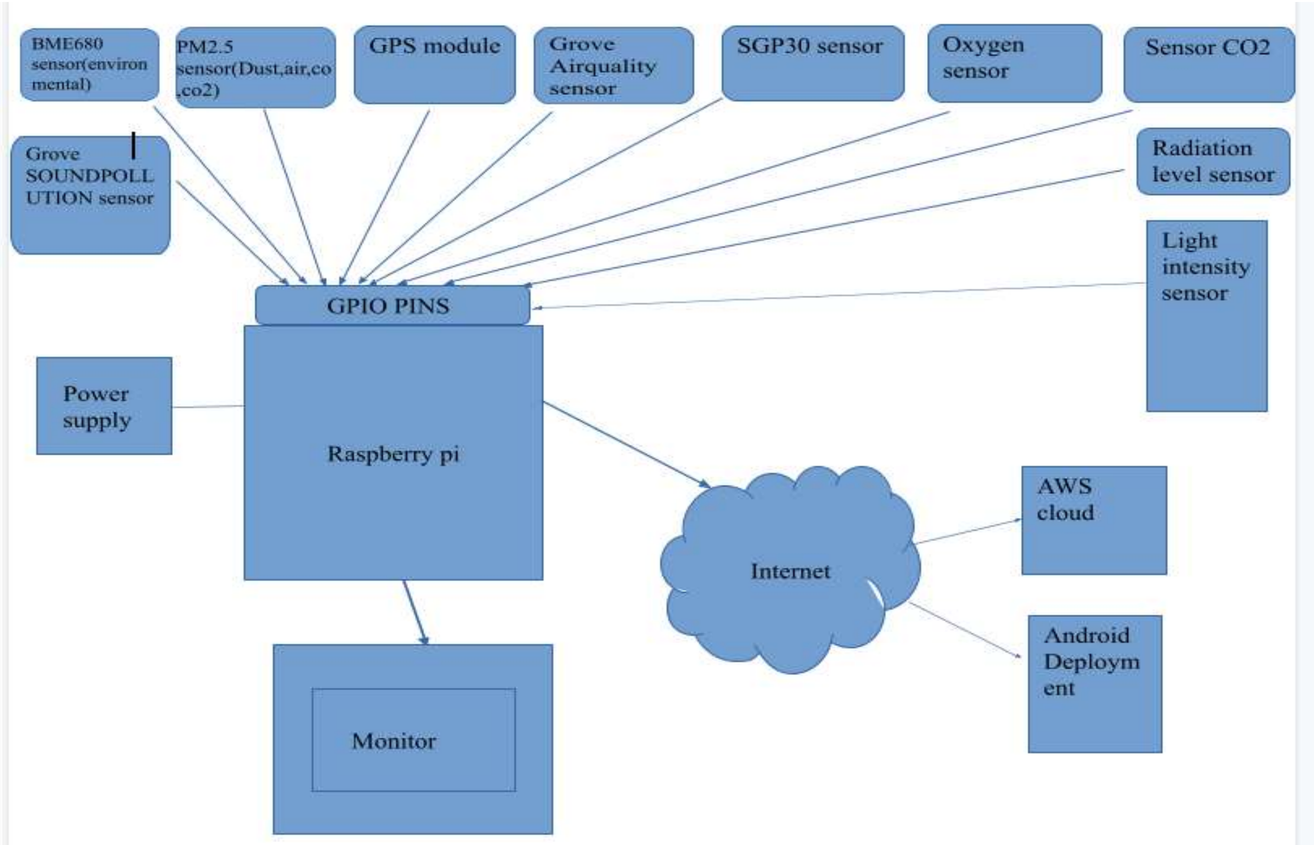

Figure 1:GRS System Model

V. Flowchart Pipeline:

Step 1: Connected with Seed grove different multiple sensors on the raspberry pi Edge device.

Step 2: All Grove Analog, Digital, I2c, and Raspberry Pi GPIO sensors are properly fitted with grove shields corresponding with an edge.

Step 3: GPS modules are connected to Raspberry Pi.

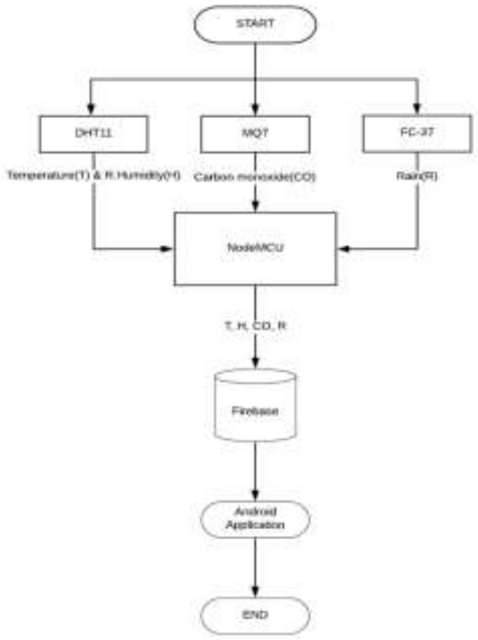

Figure 2: Flow Chart

Step 4: When the system was ready just give the power supply for Raspberry Pi 4b

Step 5: Now check that all sensors' values are populating

Step 6: Storing the values in JSON format

Step 7: Push the JSON file into AWS Cloud

Step 8: Android Mobile displays the data in a user-friendly way.

VI. R&D Implementation:

The custom-built GRS monitoring system used for this project was developed on a Raspberry Pi 4B Plus module. This module is a low-power, compact, easily configurable SBC that is powered by an ARM Cortex-A53 processor. The Raspberry Pi module encompasses features such as a Micro SD port for external storage access, Bluetooth, wireless LAN, USB ports, and GPIO pins for external communication. A nine-port expansion board was integrated into the Raspberry Pi module. A Wi-Fi USB adapter was connected to the Gigabit Ethernet port to establish access to the internet. In order to dissipate excess operational heat, a dual fan and heat sink module was attached to the Raspberry Pi system. Figure 1.2 shows the custom-built GRS monitoring system. Figure 1.2 depicts a detailed block diagram with all electrical connections. The aim of this project is to present a comprehensive indoor Environment quality monitoring system using a low-cost Raspberry Pi with Seed studio grove pi Hat-based GPS air quality sensor modules. The custom-built system measures 10 indoor environmental conditions including pollutants: Air Quality (AQI), Temperature, relative humidity, pressure, Altitude, Radiation level, Light intensity, Carbon monoxide (CO), Oxygen(O2), Carbon dioxide (CO2), and Total Volatile Organic Compounds (TVOCs). A residential unit and an educational office building, traffic signal points, were selected and monitored over a span of several months The recorded mean air quality concentrations were significantly higher in the residential unit compared to the office building. The mean O2, CO2, and TVOC concentrations were comparatively similar for both locations.

VII. Specifications of sensors used in the GRS system

Measured Parameter	Example Product	Manufacturer	Measuring Range	Accuracy (Repeatability)	Approx. Price (USD). 2019
Temp	BME680	CISCO	40 C–80 C;	0.5 C; 1%	$20
RHT	BME680	CISCO	0% to 100% 0% to 100%	0.5 C; 1%	$10
Smoke	SDS011	Nova Fitness	0.0–999.9 g /m^3	15%; 10 g/m^3	$30
Air Quality	Grove Air Quality	Seed studio	0–10 ppm	15%	$75
SO_2	Grove	Seed studio	0–20 ppm	15%	$75
CO_2	Grove SP30	Seed studio	0–5000 ppm	30%	$80
O2	Grove oxygen	Seed studio	0–1000 ppm	15%	$75
Radiation level, light intensity	Grove UV sensor	Seed studio	0–10 index	30%	$75
TVOC	Grove SGP30	Seed studio	0–500 IAQ index	30%	$95
Noise levels	Grove noise level	Seed studio	0-1024 range	30%	$20
pressure	BME680	60][0vdfhencisco	300-100hpa	30%	

The figure below represents a Low-cost custom GRS system

Figure 3: Low-cost GRS System

VIII. Result:

By applying data analytics to the resulting dataset, we can predict future weather forecasts.
By incorporating artificial intelligence tools, It is possible to significantly increase the reliability of weather and sustainability predictions.
Weather models can be made much more accurate by using these tools not only to quickly process huge amounts of weather data but to offer a more refined approach the more the models are used.

Model JSON and Dataset:


```
{
  "grs_data": [
    {
      "Date": "27_01_23",
      "Time": "08:57:27",
      "Temperature": [
        23.37,
        "C"
      ],
      "Pressure": [
        1011.96,
        "hpa"
      ],
      "Humidity": [
        54.96,
        "%RH"
      ],
      "GRS-id": 1
    }
  ]
}
```


Figure 4: GRS Output File


```
{"grs_data": [{"grs_data": [{"Date": "27_01_23", "Time": "09
:14:38", "Temperature": [23.43, "C"], "Pressure": [1011.99,
"hpa"], "Humidity": [55.75, "%RH"], "GRS-id": 1}]},
[{"grs_data": [{"Date": "27_01_23", "Time": "08:57:27",
"Temperature": [23.37, "C"], "Pressure": [1011.96, "hpa"],
"Humidity": [54.96, "%RH"], "GRS-id": 1}]}, [{"grs_data":
[{"Date": "27_01_23", "Time": "08:57:16", "Temperature":
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.95, "%RH"], "GRS-id": 1}]}, [{"grs_data": [{"Date":
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, "Pressure": [1011.96, "hpa"], "Humidity": [55.36, "%RH"],
"GRS-id": 1}]}, [{"grs_data": [{"Date": "19_01_23", "Time":
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.18, "hpa"], "Humidity": [64.91, "%RH"], "GRS-id": 1}]},
[{"grs_data": [{"Date": "19_01_23", "Time": "11:35:13",
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"Humidity": [65.02, "%RH"], "GRS-id": 1}]}, [{"grs_data":
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.31, "%RH"], "GRS-id": 1}]}, [{"grs_data": [{"Date":
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, "Pressure": [1016.24, "hpa"], "Humidity": [65.41, "%RH"],
"GRS-id": 1}]}, [{"grs_data": [{"Date": "19_01_23", "Time":
```


Figure 5: Result Dataset

We developed a mobile app for users, to get notifications whenever the environment’s temperature or humidity range exceeds the normal human sustainable range, this can be used in any of the organizations, public places, or Factories.

This Mobile app finds the levels and triggers a notification If any value is found to be High.

GRS Mobile App Home Screen:

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