Journal of **N**onlinear **A**nalysis and **O**ptimization
Vol. 14, No. 2, No.02 (2023)
ISSN : **1906-9685**

A WEATHER MONITORING SYSTEM BASED ON INTERNET OF THINGS (IOT)

Anil Kumar B, Assistant Professor, Department of ECE, GMR Institute of Technology, Rajam Andhra Pradesh, India, Corresponding author: anilkumar.b@gmrit.edu.in
Pavan Kumar Kondaka, [3]Shyamendra Kolla Students, Department of ECE, GMR Institute of Technology Rajam, Andhra Pradesh, India

Abstract—Iot-based Weather Monitoring System leverages a network of interconnected sensors and devices to collect, process, and disseminate weather-related data. The system includes various components such as weather sensors (temperature, humidity, pressure, wind speed, and precipitation), data processing units, communication modules, and a central data repository.The collected data is transmitted to a centralized cloud-based platform, where it is processed, analyzed, and made accessible to users through web-based or mobile applications. The system leverages advanced data analytics and machine learning algorithms to predict weather patterns and provide weather forecasts with enhanced precision. Users can access the system to obtain real-time updates, historical weather data, and customizable alerts, making it valuable for various applications, including agriculture, transportation, disaster management, and everyday planning..
Keywords—Arduino board, weather station, internet of things, wireless sensors, smart environment, wifi module.

INTRODUCTION

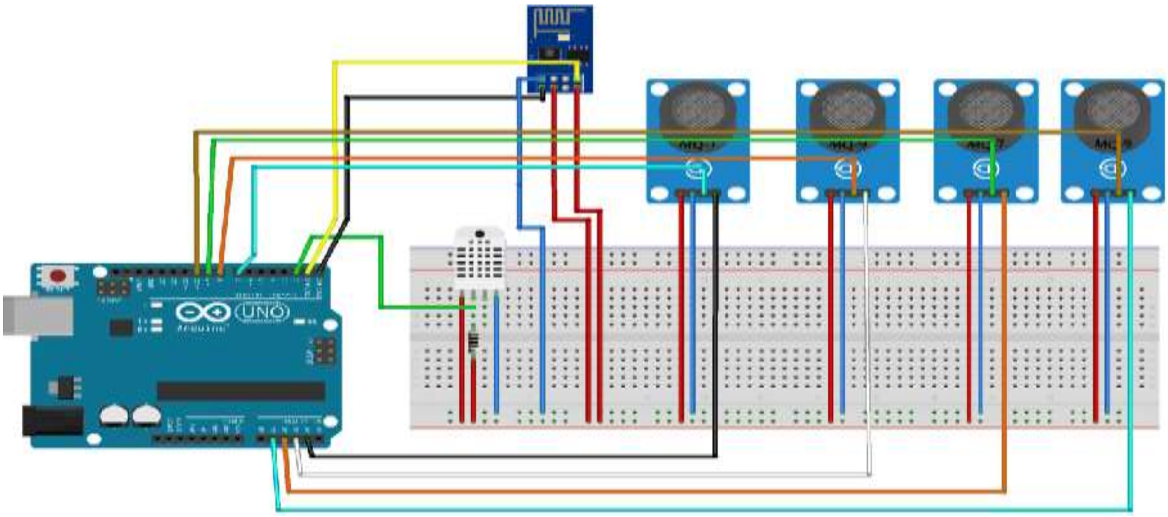
All common domains are now impacted by the Internet of Things (IoT) application. The internet of Things (IoT) technologies that have been developed try to regulate, manage, and observe routine human actions. Therefore, all of these technologies were created to simplify life and facilitate human effort.

And also we can say that some of the specifications of environmental monitoring system are equivilant to weather monitoring system. Environmental monitoring systems are created at this point to measure and regulate environmental parameters. The sensors, like temperature, humidity, and pressure sensors, form the foundation of the most modern environmental monitoring systems. Various weather conditions can be supported by some of these sensors. Others, however, have certain requirements. The corresponding physical or chemical weather values can be captured by these sensors, and they can then transform them into an electric signal. As a result, an electronic card receives the collected values as an electric signal. In this study, we suggest a framework for weather monitoring system. Technology from the internet of things supports our system. The Arduino card is a key component of our system. In fact, it has the ability to analyze the measured value and make certain choices.It can also be seen as the link between the monitoring application and the sensors.

In this context, we propose a framework of weather monitoring station in this paper. Our system is based on internet of things technology. In our system, the Arduino card plays a fundamental role. In fact, it can process the measured value and take some decisions. It can also be considered as the intermediate between the sensors and the monitoring application. The local 26 Big Data Mining and Analytics, March 2021, 25–32 and remote communications between our system and other correspondent devices are provided through Wi-Fi module..

REATED WORK

The Arduino Uno R3 is a widely used microcontroller board that is part of the Arduino platform. It is designed for hobbyists, students, and professionals who want an easy-to-use and versatile platform for building and experimenting with electronics projects. Here are some key features and information about the Arduino Uno R3:



Arduino Uno is a microntroller board based on the ATmega328P . It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator (CSTCE16M0V53-R0), a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. You can tinker with your Uno without worrying too much about doing something wrong, worst case scenario you can replace the chip for a few dollars and start **over** again.

Microcontroller: The Arduino Uno R3 is powered by the ATmega328P microcontroller, which is a member of the AVR family. It runs at 16 MHz and has 32KB of flash memory for program storage.

Digital and Analog I/O: The board features a total of 14 digital input/output pins, six of which can be used as PWM (pulse-width modulation) outputs. It also has six analog input pins.

Voltage Regulator: The board has a built-in voltage regulator that allows it to be powered from an external power source between 7V and 12V or through the USB connection to a computer.

USB Interface: The Arduino Uno R3 can be connected to a computer via USB, making it easy to program and upload code. It appears as a virtual COM port on the computer.

Programming Language: Arduino boards are typically programmed using the Arduino IDE (Integrated Development Environment), which uses a simplified version of C and C++.

Input/Output Protection: The board is equipped with protection circuits to prevent overcurrent and reverse voltage. It also includes a reset button.

Compatibility: The Arduino Uno R3 is compatible with a wide range of shields (add-on boards) designed for various applications. These shields can be stacked on top of the board to expand its capabilities.

Open-Source: The Arduino platform is open-source, which means that the hardware and software designs are freely available, allowing users to modify and customize their boards and projects.

Versatile Applications: The Arduino Uno R3 is suitable for a wide variety of applications, from simple LED blinking projects to more complex tasks like home automation, robotics, data logging, and more.

Community and Support: Arduino has a large and active community of users, making it easy to find tutorials, documentation, and assistance when working on projects.

"Uno" means one in Italian and was chosen to mark the release of Arduino Software (IDE) 1.0. The Uno board and version 1.0 of Arduino Software (IDE) were the reference versions of Arduino, now evolved to newer releases. The Uno board is the first in a series of USB Arduino boards, and the reference model for the Arduino platform; for an extensive list of current, past or outdated boards see the Arduino index of boards.

The Arduino Uno R3 is a widely used microcontroller board that is part of the Arduino platform. It is designed for hobbyists, students, and professionals who want an easy-to-use and versatile platform for building and experimenting with electronics projects.

METHODOLOGY

Wifi-Module:

A Wi-Fi module is a hardware component that provides wireless internet connectivity to devices and systems. These modules are designed to simplify the integration of Wi-Fi capability into various applications, including IoT (Internet of Things), consumer electronics, industrial equipment, and more. Wi-Fi modules are equipped with Wi-Fi radio transceivers, antennas, and often include additional components for wireless networking.

A Wi-Fi module is a hardware component that provides wireless internet connectivity to devices and systems. These modules are designed to simplify the integration of Wi-Fi capability into various applications, including IoT (Internet of Things), consumer electronics, industrial equipment, and more.

The WiFi module has emerged as a game-changing technology in the world of wireless communication. In a world increasingly reliant on the internet for information, entertainment, and connectivity, WiFi modules have become an indispensable component of modern life. This essay explores the significance, evolution, applications, and future prospects of WiFi modules.

I. The Significance of WiFi Modules:

WiFi, short for Wireless Fidelity, has revolutionized the way we connect to the internet. WiFi modules are the underlying technology that enables wireless communication between devices and networks. They have made it possible for people to access the internet and share data seamlessly without the need for physical cables. The significance of WiFi modules lies in their ability to provide high-speed, reliable, and convenient internet access in a wide range of environments, from homes and businesses to public spaces and industrial applications.

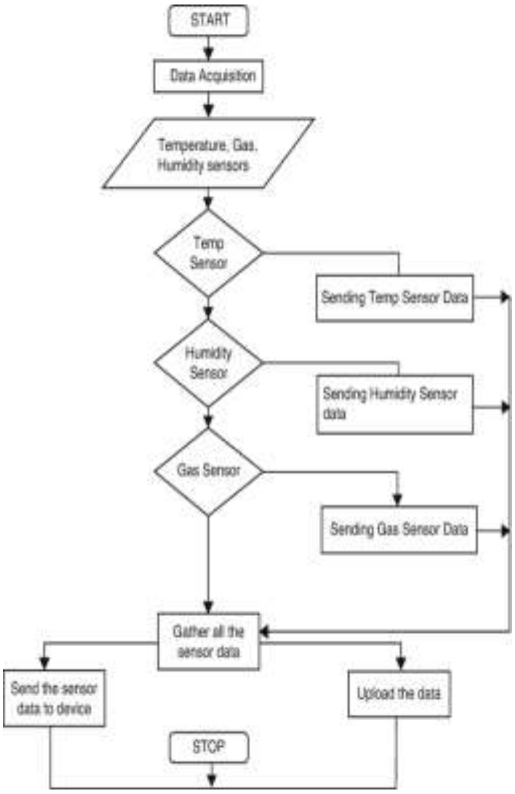
II. Evolution of WiFi Modules:

The development of WiFi modules can be traced back to the early 1990s, when a group of engineers at NCR Corporation and AT&T Corporation first conceptualized the idea of wireless local area networking (WLAN). The first WiFi standard, IEEE 802.11, was established in 1997, paving the way for the commercialization of WiFi technology. Over the years, WiFi modules have evolved significantly in terms of speed, security, and compatibility with various devices.

Environmental Impact Studies: The MQ-131 sensor can be used in environmental impact studies to assess the influence of ozone concentrations on local weather patterns and air quality. Researchers can monitor ozone levels to better understand the effects of human activities or natural events on the environment.

Weather Stations: In comprehensive weather monitoring systems or environmental monitoring stations, the MQ-131 sensor can be integrated alongside other sensors like those for temperature, humidity, wind speed, and direction. This allows meteorologists and environmental scientists to collect a wide range of data, including ozone information, which may indirectly affect weather predictions and reports.

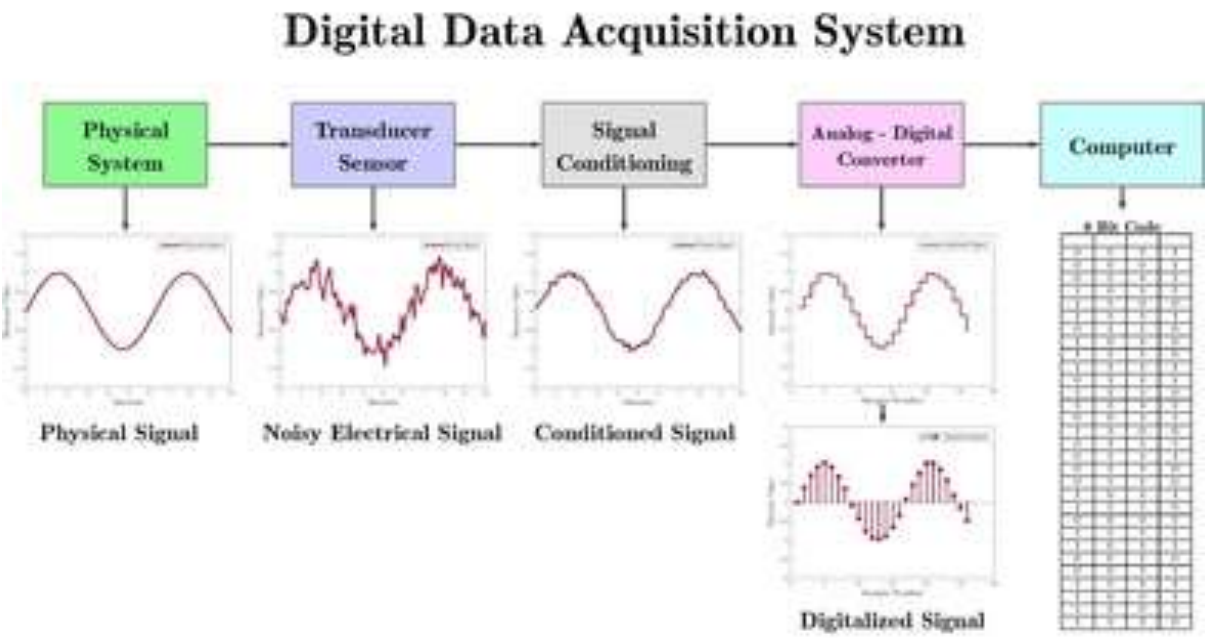
Air Pollution and Weather Patterns: Ozone is a critical component of the complex chemistry of the atmosphere. Its presence or absence can influence chemical reactions.



Data Acquisition System:

Data acquisition system (or DAS or DAQ) converts physical conditions into digital form, for further storage and analysis.

Typically, signals from sensors (sometimes processed by sensor conditioners) are sampled, converted to digital, and stored by a computer, or by a standalone device.



Sensors & Trannsducers: These are the devices that capture physical data. Sensors convert physical parameters (e.g., temperature, pressure, voltage, or light) into electrical signals, which can be processed by the DAS.

DHT11 SENSOR:

The DHT11 is a low-cost and widely used digital temperature and humidity sensor that plays a significant role in weather monitoring systems. Here's a brief overview of the DHT11's application in weather monitoring systems:

Temperature and Humidity Sensing: The DHT11 sensor is designed to measure both temperature and humidity levels in the surrounding environment. It utilizes a calibrated digital signal output to provide accurate readings.

Compact and Affordable: The DHT11 is known for its compact size, making it suitable for various weather monitoring applications. Its affordability makes it accessible to both hobbyists and professionals.

Weather Stations: In weather monitoring systems, the DHT11 is often integrated into weather stations. It provides real-time temperature and humidity data that are crucial for weather forecasting and monitoring. Weather stations equipped with DHT11 sensors can collect local weather data, enabling the generation of weather reports and predictions.

Climate Research: The DHT11 is used in climate research to record temperature and humidity data over extended periods. Researchers and environmental scientists rely on this data to analyze climate trends, study the effects of climate change, and assess the impact of humidity on weather patterns.

Local Weather Monitoring: DHT11 sensors are commonly utilized for local weather monitoring in homes, schools, and small communities. They enable individuals to access real-time weather information, helping with daily planning and decision-making.

Greenhouses and Agriculture: The DHT11 sensor is valuable in agricultural applications. It can be employed in greenhouses to monitor temperature and humidity levels, which are crucial for optimizing plant growth and crop yields. By maintaining ideal conditions, farmers can increase their productivity.

Weather Alerts and Alarms: In weather monitoring systems, DHT11 sensors can be integrated into alert and alarm systems. When temperature or humidity levels exceed predefined thresholds, these sensors trigger alarms, notifying individuals of potential weather-related issues like extreme temperatures or high humidity, which can affect crop health or infrastructure.

Educational Purposes: The affordability and simplicity of DHT11 sensors make them suitable for educational purposes. They are often used in classrooms to teach students about weather monitoring, data collection, and the principles of temperature and humidity measurements.

Data Logging and Analysis: Data collected from DHT11 sensors can be logged over time for analysis. This historical data is valuable for studying weather patterns and trends, helping meteorologists and climate scientists gain a deeper understanding of regional climates.

Internet of Things (IoT) Integration: DHT11 sensors can be incorporated into IoT projects to create a network of interconnected weather monitoring devices. These devices can relay real-time weather data to online platforms and mobile applications, providing weather information to a broader audience.

MQ-7:

The MQ-7 is a gas sensor module primarily designed for the detection of carbon monoxide (CO) in the atmosphere. While its primary function is not directly related to weather monitoring, it can have some applications and implications in this context. Here's a brief overview of the MQ-7 sensor's potential role in a weather monitoring system:

Air Quality and Weather Monitoring: Carbon monoxide is a colorless, odorless gas that can be emitted from various sources, including vehicle exhaust, industrial processes, and natural phenomena such as wildfires. Elevated levels of CO in the atmosphere can have an impact on air quality and weather conditions. In a weather monitoring system, the MQ-7 sensor can be employed to measure CO concentrations.

Weather Stations: In comprehensive weather monitoring systems or environmental monitoring stations, the MQ-7 sensor can be integrated alongside other sensors like those for temperature, humidity, wind speed, and direction. This allows meteorologists and environmental scientists to collect a wide range of data, including air quality information, which may indirectly affect weather predictions and reports.

Environmental Impact Studies: The MQ-7 sensor can be used in environmental impact studies to assess the influence of carbon monoxide emissions on local weather patterns and air quality. Researchers can monitor CO levels to better understand the effects of human activities or natural events on the environment.

Safety and Health Alerts: Elevated levels of carbon monoxide can pose health risks to humans, and monitoring CO concentrations is crucial for safety. In cases where weather conditions influence CO dispersion (e.g., temperature inversions), the MQ-7 sensor can be used to trigger safety and health alerts to protect the public from exposure to high CO levels.

It's important to note that while the MQ-7 sensor can provide valuable data on carbon monoxide concentrations and its potential effects on air quality and weathr patterns, it is typically used in conjunction with other sensors and meteorological instruments to create a comprehensive picture of weather and environmental conditions. The integration of CO data from the MQ-7 sensor into broader weather monitoring and prediction systems can enhance our understanding of the complex relationship between air quality, air pollution, and weather.

MQ-131:

The MQ-131 is a gas sensor module designed to detect ozone (O3) gas concentrations in the atmosphere. While its primary function is not directly related to weather monitoring, it can have applications and implications in this context. Here's a brief overview of the MQ-131 sensor's potential role in a weather monitoring system:

Ozone and Weather Monitoring: Ozone is a crucial component of the Earth's atmosphere, existing in two layers: the ozone layer in the stratosphere and ground-level ozone in the troposphere. Ground-level ozone is a pollutant that can impact air quality, human health, and weather patterns. In a weather monitoring system, the MQ-131 sensor can be used to measure ground-level ozone concentrations.

MQ-136:

Air Quality and Weather Patterns: Elevated levels of ground-level ozone can have an impact on air quality and, subsequently, on local weather conditions. Ozone is a greenhouse gas, and its presence can contribute to temperature inversions and the formation of smog. Monitoring ozone levels using the MQ-131 can provide insights into the relationship between air quality, greenhouse gases, and weather.

Signal Conditioning: The raw signals from sensors often need to be conditioned to ensure they are accurate and within the desired measurement range.

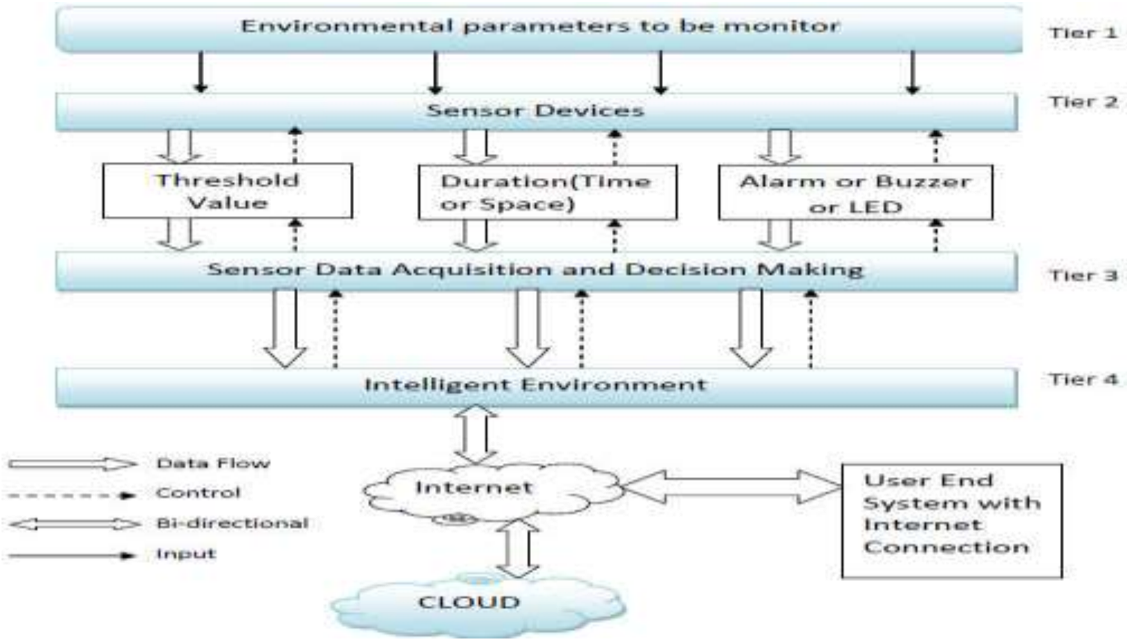
Analog-to-Digital Conversion(ADC): Analog signals from sensors are converted into digital format by an ADC. The digital data can be easily processed, stored, and transmitted by computer systems.

Data Processing and Analysis: The DAS may include processing capabilities for real-time data analysis or filtering to remove noise or irrelevant information. Complex algorithms can be used for advanced data interpretation

III.Proposed methodology:

The proposed Embedded device is for monitoringTemperature, Humidity, Pressure, light intensity, sound intensity levels and CO levels in the atmosphere to make the environment intelligent or interactive with the objects through wireless communication. The proposed model is shown in figure 2 which is more adaptable and distributive in nature to monitor the environmental parameters.The proposed architecture is discussed in a 4- tier model with the functions of each individual modules developed for noise and air pollution monitoring. The proposedmodelconsistsof 4-tiers. The tier 1 is the environment,

Sensor devices in tier 2, sensor data acquisition and decision making in tier 3 and intelligent environment in tier 4.The proposed architecture is shown in figure 2. Here, the tier 1 provides information about the parameters under the region which is to be monitored for noise and air pollution control. Tier 2 deals with the sensor devices with suitable characteristics, features and each of these sensor devices are operated and controlled based on their sensitivity as well as the range of sensing in between tier 2 and tier 3 necessary sensing and controlling actions will be taken depending upon the conditions, like fixing the threshold value, periodicity of sensing, messages (alarm or buzzer or LED) etc. Based on the data analysis performed in between tier 2 and tier 3 and also from previous experiences the parameter threshold values during critical situations or normal working conditions are determined.Tier 3 describes about the data acquisition from sensor devices and also includes the decisionvmaking. Which specify the condition the data is representing which parameter.
In the proposed model tier 4 deals with the intelligent environment. Which means it will identify the variations in the sensor data and fix the threshold value depending on the identified level of CO or noise levels. In this tier sensed data will be processed, stored in the cloud i.e.in to the Google spread sheets and also it will show a trend of the sensed parameters with respect to the specifiec values.The end users can browse the data using mobile phones, PCs etc.



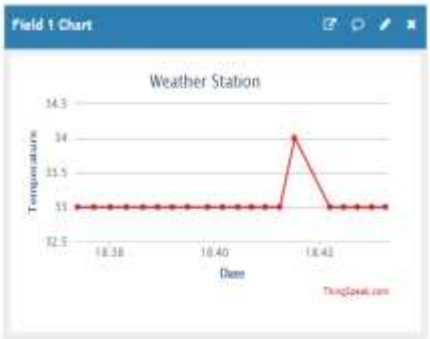
Here, the tier 1 provides information about the parameters under the region which is to be monitored for noise and air pollution control. Tier 2 deals with the sensor devices with suitable characteristics, features and each of these sensor devices are operated and controlled based on their sensitivity as well as the range of sensing. In between tier 2 and tier 3 necessary sensing and controlling actions will be taken depending upon the conditions, like fixing the threshold value, periodicity of sensing, messages (alarm or buzzer or LED) etc. Based on the data analysis performed in between tier 2 and tier 3 and also from previous experiences the parameter threshold values during critical situations or normal working conditions are determined.Tier 3 describes about the data acquisition from sensor devices and also includes the decision making. Which specify the condition the data is representing which the table gives.

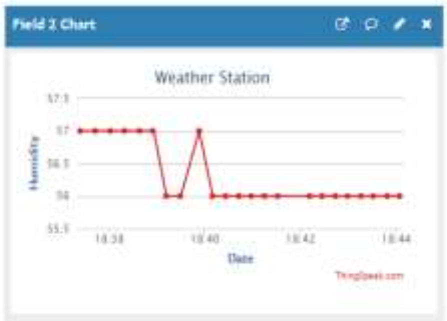
RESULTS

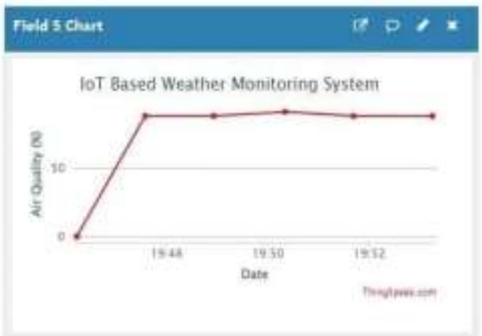
A.WEATHER STATION

The implementation of a system for monitoring environmental parameters using the IoT has been tentatively tested to verify air and weather parameters. The system provides a low energy consumption solution for the establishment of a station weather system. The system is tested in an indoor environment and it successfully updated the environment and weather conditions from sensor data. It is also a less expensive solution thanks to the use of low power consumption wireless sensors and System-on-Chip (SoC) contains a Wi-Fi module. This information will be useful for future review and tend to be shared effectively with various users. This model can also be extended to the observation of contamination in new and modern urban areas. To protect the general well-being from contamination, this model provides an effective and minimal effort response for continuous observation.

Items	Specification
Number of pixel (thermal sensors)	64 (Vertical 8 × Horizontal 8)
Field of view	60°×60°
Interface	I²C (fast mode)
Human detection distance	Max. 5 m
Operating voltage	3.3 VDC
Sensing range of wavelength	8 μm to 13 μm
Frame rate	10 fps or 1 fps
Operating mode and current consumption	Normal - 4.5mA Sleep - 0.2 mA Stand-by – 0.8 mA
Temperature output resolution	0.25 °C
Sensing temperature range	0 °C to 100 °C
Number of sensor address	2 (I²C slave address)
Package size	11.6 mm × 8 mm × 4.3 mm
Price	24 USD







B.IOT SYSTEM

The graph in figure 8 (a) shows the sound intensity levels during day time at regular time intervals. The graph 8 (b) shows the sound intensity levels during night time. The graph 8(c) shows the average sound intensity levels during entire day. Depending on the average value, threshold value will be decided.graph in figure 9(a) shows the CO levels in city environment with full traffic at regular time intervals. The graph 9(b) shows the CO levels in city environment without traffic.

C.AVARAGE VALUES

The graph 9(c) shows the average CO levels during entire day. After completing the analysis on sensed data, the threshold value will be set for necessary controlling actions. By keeping the embedded devices in the environment for monitoring enables self protection (i.e., smart environment) to the environment. To implement this need to deploy the sensor devices in the environment for collecting the data and analysis. By deploying sensor devices in the environment, we can bring the environment into real life i.e. it can interact with other objects through the network. Then the collected data and analysis results will be available to the end user through the Wi-Fi. The smart way to monitor environment and an efficient, low cost embedded system is presented with different models in this paper.

In the proposed architecture functions of different modules were discussed. The noise and air pollution monitoring system with Internet of Things (IoT) concept experimentally tested for monitoring two parameters. It also sent the sensor parameters to the cloud (Google Spread Sheets). This data will be helpful for future analysis and it can be easily shared to other end users. This model can be further expanded to monitor the developing cities and industrial zones for pollution monitoring. To protect the public health from pollution, this model provides an efficient and low cost solution for continuous monitoring of environment

CONCLUSION

To confirm air and weather parameters, a prototype system for IoT-based environmental parameter monitoring has been evaluated. The system offers a station weather system setup option with little energy consumption. The system was tested indoors, and it updated the surroundings and weather conditions successfully using sensor data. Due to the usage of wireless sensors with low power consumption and the fact that the System-on-Chip (SoC) has a Wi-Fi module, it is also a less expensive solution. Future reviews of this knowledge will be helpful, and it usually gets properly transferred forward to different people. This model can be expanded to include the detection of contamination in current and new urban settings. This design protects the general health from pollution.

REFERENCES

- K. S. S. Ram and A. N. P. S. Gupta, IoT based data logger system for weather monitoring using wireless sensor networks, International Journal of Engineering Trends and Technology, vol. 32, no. 2, pp. 71–75, 2016.
- B. S. Rao, D. K. S. Rao, and N. Ome, Internet of Things (IoT) based weather monitoring system, International Journal of Advanced Research in Computer and Communication Engineering, vol. 5, no. 9, pp. 312– 319, 2016.
- J. Mabrouki, M. Azrour, Y. Farhaoui, and S. El Hajjaji, Intelligent system for monitoring and detecting water quality, in Big Data and Networks Technologies, vol. 81
- Y. Farhaoui, ed. Cham, Germany: Springer International Publishing, 2020, pp. 172–182. [15] A.
- H. Ali, R. F. Chisab, and M. J. Mnati, A smart monitoring and controlling for agricultural pumps using LoRa IOT technology, Indonesian Journal of Electrical Engineering and Computer Science, vol. 13, no. 1, pp. 286–292, 2019.
- M. Kristo et al., "Thermal Object Detection in Difficult Weather Conditions Using YOLO," *in IEEE Access,* vol. 8, pp. 125459-125476, 2020.
- T. -Y. Huang et al., "YOLO-ORE: A Deep Learning-Aided Object Recognition Approach for Radar Systems," *in IEEE Transactions on Vehicular Technology,* vol. 72, no. 5, pp. 5715-5731, May 2023.
- J. Yu et al., "Traffic Sign Detection and Recognition in Multi-images Using a Fusion Model With YOLO and VGG Network," *in IEEE Transactions on Intelligent Transportation Systems,* vol. 23, no. 9, pp. 16632-16642, Sept. 2022.
- C. Dewi et al., "Yolo V4 for Advanced Traffic Sign Recognition with Synthetic Training Data Generated by Various GAN," *in IEEE Access,* vol. 9, pp. 97228-97242, 2021.
- V. D. A. Kumar et al., "Green-Tech CAV: Next Generation Computing for Traffic Sign and Obstacle Detection in Connected and Autonomous Vehicles," *in IEEE Transactions on Green Communications and Networking,* vol. 6, no. 3, pp. 1307-1315, Sept. 2022.
- L. Meyrowitz et al., "Autonomous vehicles," *in Proceedings of the IEEE,* vol. 84, no. 8, pp. 1147-1164, Aug. 1996.
  M. Liu et al., "LF-YOLO: A Lighter and Faster YOLO for Weld Defect Detection of X-Ray Image," *in IEEE Sensors Journal,* vol. 23, no. 7, pp. 7430-7439, 1 April1, 2023.
- H. Du et al.,"Autonomous landing scene recognition based on transfer learning for drones," *in Journal of Systems Engineering and Electronics,* vol. 34, no. 1, pp. 28-35, February 2023

- G. Li et al., "Cross-Domain Object Detection for Autonomous Driving: A Stepwise Domain Adaptative YOLO Approach*," in IEEE Transactions on Intelligent Vehicles,* vol. 7, no. 3, pp. 603-615, Sept. 2022.
- M. Kristo et al., "Thermal Object Detection in Difficult Weather Conditions Using YOLO," *in IEEE Access,* vol. 8, pp. 125459-125476, 2020.
- T. -Y. Huang et al., "YOLO-ORE: A Deep Learning-Aided Object Recognition Approach for Radar Systems," *in IEEE Transactions on Vehicular Technology,* vol. 72, no. 5, pp. 5715-5731, May 2023.
- J. Yu et al., "Traffic Sign Detection and Recognition in Multi-images Using a Fusion Model With YOLO and VGG Network," *in IEEE Transactions on Intelligent Transportation Systems,* vol. 23, no. 9, pp. 16632-16642, Sept. 2022.
- C. Dewi et al., "Yolo V4 for Advanced Traffic Sign Recognition with Synthetic Training Data Generated by Various GAN," *in IEEE Access,* vol. 9, pp. 97228-97242, 2021.
- V. D. A. Kumar et al., "Green-Tech CAV: Next Generation Computing for Traffic Sign and Obstacle Detection in Connected and Autonomous Vehicles," *in IEEE Transactions on Green Communications and Networking,* vol. 6, no. 3, pp. 1307-1315, Sept. 2022.
- L. Meyrowitz et al., "Autonomous vehicles," *in Proceedings of the IEEE,* vol. 84, no. 8, pp. 1147-1164, Aug. 1996.