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Monitoring and Analysis of Environmental Data Using IoT and Machine Learning

Jyoti P. Wani, PG Student, SVIT, Chincholi, Nashik, India, suljyoti@gmail.com

Prof. Ulhas V. Patil, HOD E&TC Dept. , SVIT, Chincholi, Nashik, India, ulhas.patil@pravara.in

Prof. Archana A. Hatkar, Asst. Prof., SVIT, Chincholi, Nashik, India, archana.hatkar@pravara.in

Abstract-: In the recent times, we have seen extreme growth in industrialization, urban cities and population, which pose a monumental threat to the environment. Both qualitative and quantitative detection of parameters in all environmental coordinates has always been a challenge. With the latest advances in Internet of Things, we can monitor the environmental factors with greater ease. This work proposes the use of Internet of Things architecture to monitor different environmental factors like Temperature, Humidity, Air Quality and Light Intensity. Using Internet of Things the data from sensors can be continuously collected and analysed. Thus, timely detection of unusual environmental parameters can help in reducing the environmental problems and work towards providing a better surrounding. The system consists of two sensor nodes and a gateway. The gateway collects data from sensor node at regular intervals and then shares that data for private channels so that we can analyze the data and make the appropriate decisions. The values for environmental parameters are predicted using data set and the higher officials in that area can be notified if the actual values are beyond the predicted range. The results and the performance of the proposed system is discussed.

***Keywords* — Internet of Things (IoT), Wireless Sensor Node, Environmental Monitoring, Gateway, Data Set.**

I. INTRODUCTION

The Internet of Things is the combination of embedded system, which has sensors and actuators to interact with the physical world and the internet, which provides ubiquitous remote and secure communication.

In recent days technology advances helps to grow IOT domain rapidly. With the fast growing IOT field also have few of challenges such as sensing physical world, connectivity issues, security, and power issue.

IOT has the potential to make the world more hospitable for present and future generations of humanity. IOT helps to improve the lifestyle of society by giving them the better quality of services in fields such as air quality management, traffic and parking management, energy consumption management and building automation.

Global environment situation of the earth is becoming increasingly problematic and critical and there are a lot of parameters such as population, industrialization, which directly or indirectly effects on the quality of the environment and results in a greater impact on the social and economic front of a human being. In order to provide the solution for a human to adopt with environmental change an automated and continuous monitoring of environment is needed. Environment monitoring can be defined as it is a process sampling of air, water, the soil in order to study the environmental parameter, as well as derive the knowledge from this process and describe the quality of the environment. Temperature, Humidity, and CO_2 are the basic parameters for the most of these services. EMS has to play an important role in future smart cities for application such as urban Air Quality, Weather forecasting, Protection of water supplies etc.

A wireless system is not a single device, but a collection of devices which operate interdependently. The wireless sensor network is a self-configured network being composed of a large number of sensors. WSNs provide an efficient and flexible monitoring system for indoor as well as outdoor applications. We implemented a star topology of WSN which contains two sensor nodes and one gateway devices. Sensor node measures the surrounding temperature, humidity and CO_2 concentration in the environment with low power consumption, and transmits the collected sample readings to gateway through Wi-Fi protocol.

After collecting sensor data from different sensor nodes gateway publishes the sensor node data on the cloud. The sensor node is powered from the battery.

II. LITERATURE SURVEY

In 2018, Jan Sramota, Amund Skavhaug, "RailCheck: A WSN-Based System for Condition Monitoring of Railway Infrastructure"[1], uses an autonomous, near-real-time system developed using IOT, WSN and big-data processing. The performance of system was potentially beneficial for the railway sector.

Vijay R. Shinde, Pankaj P. Tasgaonkar, R. D. Garg, [2]"Environment Monitoring System through Internet of Things(IOT)", have developed a monitoring architecture using Raspberry Pi and IBM Cloud. The analysis helps in making helpful decisions.

In 2014, Qinghua Zhang,Yi Wang,Guoquan Cheng,Zhuan Wang and Dongmei Shi, "Research on Warehouse Environment Monitoring System Based on Wireless Sensor

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Network"[3], proposed a system framework for the monitoring of warehouse environment based on the technology of IOT(Internet of Things). Division of the architecture of the warehouse environment monitoring system is into 4 layers: Sensing Layers, data process Layers, Communication Layers and Application Layers. Here the environment monitoring terminals are used as end device which is based on Cortex A8.These terminals collect the environmental information. And connect to the sink node in a sensor network with serial ports, connect to the server by WLAN. The terminal sends the environmental data to the server in real time with help of WLAN. Sensor node to Sink node data is transmitted with sensor communication protocol which consists field such as Sensor Type, Sensor Id, and Data etc.

In 2016, "Jalpa Shah and Biswajit Mishrai,IOT enabled Environmental Monitoring System for Smart Cities"[5], proposed IOT enabled sensing and monitoring system consists of transmitter node(TX node) and receiver node(RX node). The sensed data from the TX node is transmitted to RX node through wireless communication. Sensed data is showen graphically and accumulated in an excel sheet through GUI, using Lab VIEW. This data can be stored in MySQL database server using internet. They operated transceiver in Shock Burst Packet Mode which allows lower data rate with the reduction in average current consumption.

In 2017, Fang Chen, Linlin Qin, Xiaofeng Li, Gang Wu, Chun Shi [6]. Wireless sensor nodes can be easily arranged in different positions in the greenhouse, completing the data acquisition and storage which consist of the greenhouse air temperature, air humidity and soil temperature. And the automatic control of the greenhouse equipment is also realized.

In 2018, Dattatraya Shinde, Naseem Siddiqui[12], "IOT Based Environment change Monitoring & Controlling in Greenhouse using WSN" proposes a system which uses various sensors to check soil humidity and light. The system helps in maintaining the soil quality which is required to grow the particular crop properly.

III. PROPOSED ARCHITECHTURE

The overall proposed architecture consists of four parts, namely, sensor nodes, the gateway, cloud service and a mobile application. Sensor nodes can be deployed in the field areas to collect environmental data such as temperature, humidity, atmospheric pressure, light intensity, air quality, rain and dust. We are implementing two such nodes in our project work and one receiver as a gateway which will receive the data from WSN and send it to cloud. Cloud service provider is used to channel the sensor values and store them.

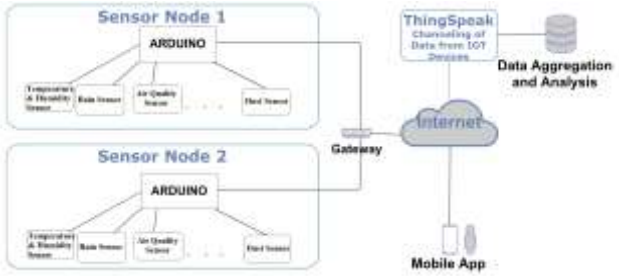

Fig 1. System Architecture

Real time environmental data can be visualized from both gateway Wi-Fi or ThingSpeak cloud. This data from sensors is used for analysis and make predictions. We calculate predicted values using the available dataset. The actual sensor data is used for comparison with predicted values. End users can view the sensor data and analysis on mobile application. Notification can be sent if environmental parameters cross safe predicted range.

A. Wireless Sensor Nodes

For measurement of real time environmental data different kind of sensors are used.

- DHT22 Sensor - Digital Temperature and Humidity

The DHT22 combines the digital temperature and humidity sensor. Capacitive humidity sensor and a thermistor is used to measure the surrounding air, and it gives digital signal on the data pin as output. Small size, low consumption, long transmission distance of 20m makes DHT22 to be suited in all kinds of harsh occasions.

- MQ-135 GAS Sensor - Air Quality Sensor

The gas sensors are used in air quality control sensing for the system and are suitable for detecting of NH3,NOx, alcohol, benzene, smoke, CO2 ,etc. It has lower conductivity in clean air. The conductivity of the sensor is higher along with the gas concentration rising, when the target combustible gas exists.

- Light Sensor

When there is no light or the light intensity cannot reach the value, D0 output is high level. When light intensity over the threshold value, the module D0 output is low level. The module digital output D0 can be directly connected to the microcontroller. It can then detect high or low level, which in turn can detect the environmental light intensity change.

- BMP280 - Atmospheric Pressure sensor

The BMP280 is an absolute barometric pressure sensor. It is the precision sensing sensor for measuring barometric pressure with ± hPa absolute accuracy, temperature with ±1.0°C accuracy, which is also low-cost.

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- GP2Y1010AU0F - Dust Sensor

GP2Y1010AU0F is a dust sensor by optical sensing system. A phototransistor and an infrared emitting diode (IRED) are diagonally arranged into the device. It detects the reflected light of dust in the air. It is very effective to detect super fine particle like cigarette smoke. In addition it can distinguish smoke from house dust by pulse pattern of output voltage.

- Rain sensor

The rain sensor module is a useful tool for rain detection. It can be used for measuring rainfall intensity and as a switch when raindrop falls through the raining board. The module features, a rain board and the control board that is separate for more convenience, power indicator LED and an adjustable sensitivity though a potentiometer.

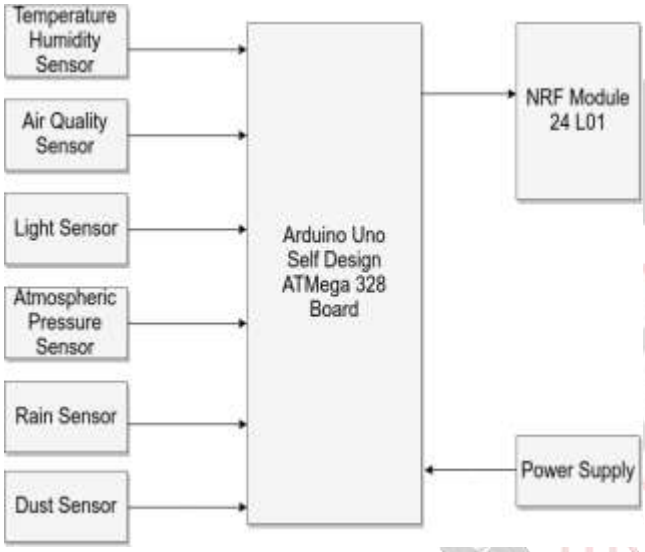

Fig 2. Wireless Sensor Node

We are implementing two nodes in our project work and one receiver as a gateway which will receive the data from WSN and send it to cloud. The wireless sensor node consists of the different environmental sensors connected to the Arduino microcontroller based on ATmega328. NRF module is single chip radio transceiver. The data from two deployed WSN will be sent to the gateway via NRF module.

B. Gateway

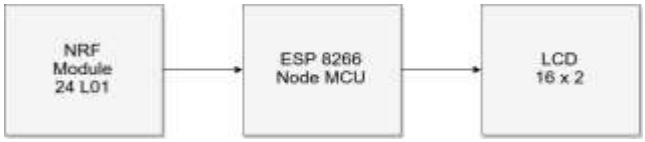

Fig 3. Receiver

Receiver uses Node MCU ESP 8266 platform for the development of IoT which will allow sending the data to the server.

Node MCU is an IOT platform which includes firmware running on ESP 8266 WiFi SoC from Espressif Systems and the hardware based on ESP-12 module.

C. ThingSpeak

ThingSpeak is an open cloud data platform where you can store and retrieve data.[14] ThingSpeak enables the creation of sensor logging applications, location tracking applications, and a social network of things with status updates. ThingSpeak acts as the IoT platform for data collection and data analysis that serves as a channel connecting sensor devices such as temperature and pressure sensors to collect data. ThingSpeak is very useful as the data collector which collects data from sensors of node devices and also enables the data to be analyzed by software environment for historical analysis of data.

D.Machine Learning Model

Machine learning model is developed using the available dataset for temperature and humidity.[13] The details of the dataset are summarized in the following table:

Data collected	Temperature (°C), Relative Humidity
Start date	12/31/1978
End date	7/30/2014
Location Area (Nashik City)	North-east corner: 20.2219, 74.0938 South-west corner: 19.9007, 73.7422
Number of days(rows)	12929

Linear regression model is used for predicting the parameter values. The date-time variable is independent variable and the temperature is considered as the dependent variable. The temperature is predicted by using the available dataset.

Reasons for using the linear regression model

- To include continuous and categorical independent variables.
- Multiple variables can be added to the model in the future
- Easy to implement for less amount of training data

Linear Regression though being the first step for statistical analysis yielded good results, as shown in the results section. The model fits perfectly and the coefficients obtained from regression were able to predict to temperature for future dates.

E. Mobile Application

Smartphones provide instant communication and easy access to information. Mobile application is type of application software designed to run on a mobile device such as a smartphone. Having mobile app on a smartphone makes it much more convenient to check data updations or notifications. For these reasons mobile application is developed for environment monitoring.

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The measured parameters from the sensors are continuously updated and are thus viewed by the user using the Monitoring Application. Also the predicted values and actual values are shown on the mobile application. Notification service is used to indicate if values go beyond a safe range.

IV. RESULTS

The following wireless sensor nodes were deployed:

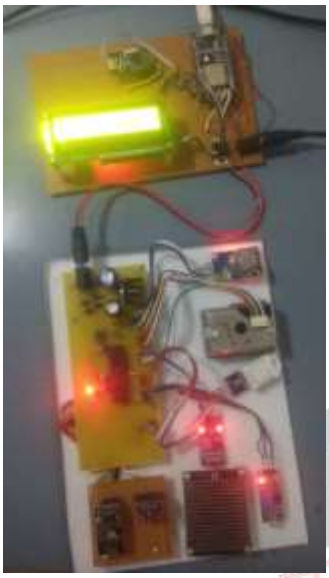
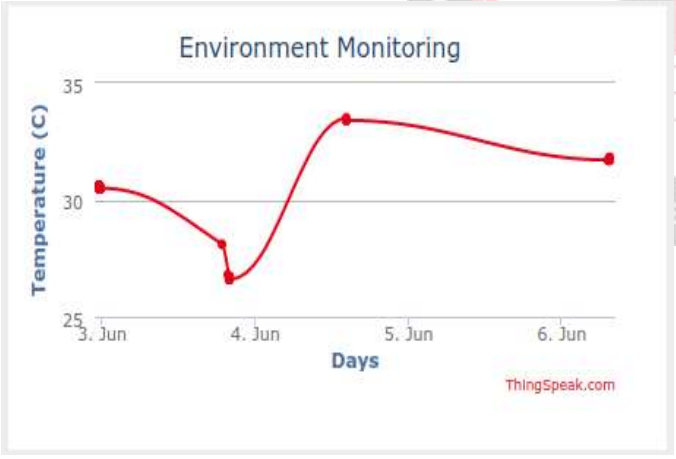
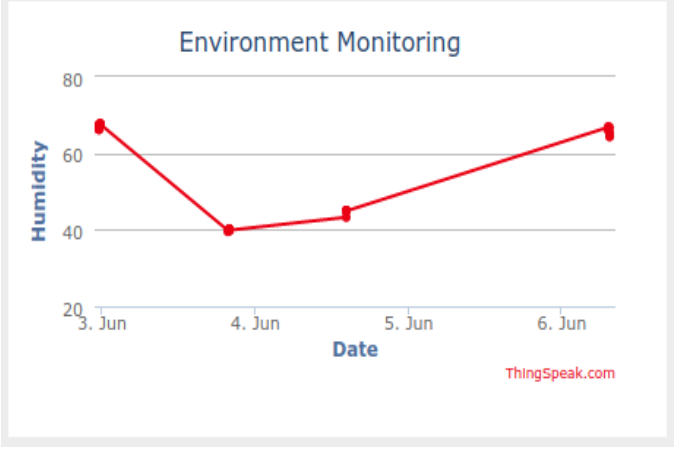


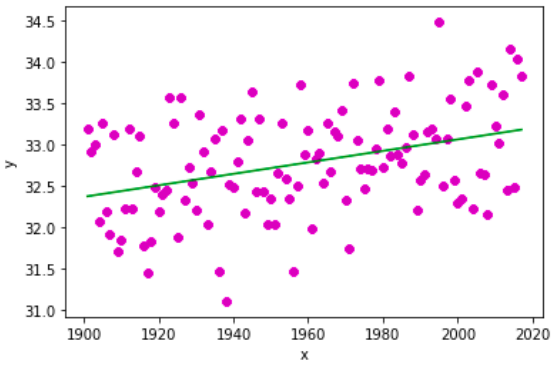
Fig 4. Receiver with LCD display and WSN mounted with sensors

Graphs of collected data vs time received on the cloud service:





Temperature vs Year, linear regression model:



Notification and App Screenshots:

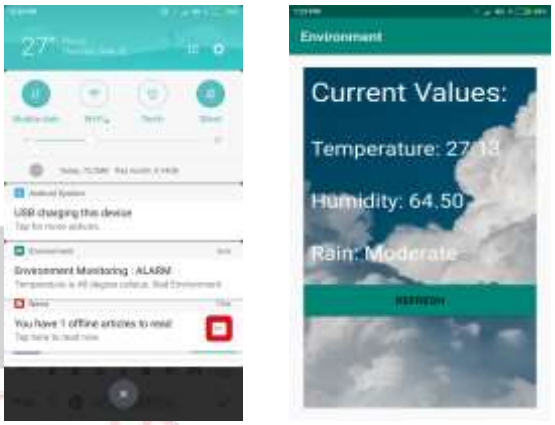


Fig. 5. App Screenshots

V. CONCLUSION

This project provides automated monitoring of quality of environment and provides solution for adaptation with environmental change. This project has multi-sensing capability with measuring various environmental parameters such as temperature, humidity, rain, light intensity, atmospheric pressure and dust. Using IoT and machine learning this project can monitor the environmental surroundings to provide alerts through mobile application if the environmental conditions exceed the optimum range. Use of two wireless nodes facilitates to compare real-time values. Also, using more than one node gives us the flexibility to use this project in multiple surroundings. ThingSpeak is used for data aggregation and analytics. According to various applications, this project can be further modified to be used for industrial safety with addition of fire sensor, for environmental pollution detection with addition of fog sensor and solar radiation sensor for campus environment monitoring with additional wireless sensor nodes.

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