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Smart weather monitoring and real time alert system using IoT

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Abstract - *The system proposed is an advanced solution for weather monitoring that uses IoT to make its real time data easily accessible over a very wide range. The system deals with monitoring weather and climate changes like temperature, humidity, wind speed, moisture, light intensity, UV radiation and even carbon monoxide levels in the air; using multiple sensors. These sensors send the data to the web page and the sensor data is plotted as graphical statistics. The data uploaded to the web page can easily be accessible from anywhere in the world. The data gathered in these web pages can also be used for future references. The project even consists of an app that sends notifications as an effective alert system to warn people about sudden and drastic weather changes. For predicting more complex weather forecast that can't be done by sensors alone we use an API that analyses the data collected by the sensors and predicts an accurate outcome. This API can be used to access the data anywhere and at any time with relative ease and can also be used to store data for future use. Due to the compact design and fewer moving parts this design requires less maintenance. The components in this project don't consume much power and can even be powered by solar panels. Compared to other devices that are available in the market the Smart weather monitoring system is cheaper and cost effective. This project can be of great use to meteorological departments, weather stations, aviation and marine industries and even the agricultural industry.*

Key Words: **Internet of Things (IoT), development boards, embedded systems, Raspberry pi, NodeMCU, ESP8266, Arduino IDE, Ubidots, and API.**

1. INTRODUCTION

Present day innovations in technology mainly focus on controlling and monitoring of different devices over wirelessly over the internet such that the internet acts as a medium for communication between all the devices. Most of this technology is focused on efficient monitoring and controlling of different. An efficient environmental monitoring system is required to monitor and assess the weather conditions in case of exceeding the prescribed level of parameters (e.g., noise, CO and radiation levels) and for gathering data for research purposes (amount of rainfall, windspeed etc.).

A system is considered as a smart system when the device equipped with sensors, microcontrollers and various software applications becomes a self-protecting and self-monitoring system. Event Detection based and Spatial Process Estimation are the two categories to which applications are classified. Initially the sensor devices are deployed in environment to detect the parameters (e.g., Temperature, Humidity, Pressure, LDR, noise, CO and radiation levels etc.) while the data acquisition, computation and controlling action (e.g., the variations in the noise and CO levels with respect to the quantified levels). Sensor devices are positioned at different locations to collect the data to forecast the behavior of a particular area of interest. The main aim of this paper is to design and implement an resourceful monitoring system through which the required parameters are monitored remotely using internet and the data gathered from the devices are stored in the cloud and to project the predictable trend on the web browser.

A solution for monitoring temperature and CO levels i.e., any parameter value crossing its threshold value ranges, for example CO levels in air in a particular area exceeding the normal levels etc., in the atmosphere using wireless embedded computing system is proposed in this paper. The solution also provides an intelligent remote monitoring for a particular area of interest. In this paper we also current results of collected or sensed data with respect to the normal or specified ranges of particular parameters. The embedded system is an integration of sensor devices, wireless communication which enables the user to remotely access the various parameters and store the data in cloud.

2. EXISTING SYSTEM

The existing weather monitoring systems generally use weather stations that use multiple instruments such as thermometers, barometers, wind vanes, rain gauge etc. to measure weather and climate changes. Most of these instruments use simple analog technology which is later physically recorded and stored in a data base. This information is later sent to news reporting stations and radio stations where the weather report is given.

2.1 Limitations of the existing System

1. Existing weather monitoring systems that are used in the field generally consist of unconventional and heavy machinery that consists of numerous moving parts that require constant maintenance and need to be manually monitored and changed frequently.

2. Power requirements are one of many major constraints as these instruments are generally sited far from main power supply. This adds to the cost of using such instruments.

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3. The use of thermometers to measure external temperature; however accurate is still outdated and constantly needs to be manually checked for any change in temperature.

4. Data that is collected by the instruments needs to be manually transferred from the logger to a laptop or computer via a cable.

5. Existing systems consist of large and heavy instruments that occupy a lot of space hence making it difficult to install them in remote location and places which have limited space.

6. The instruments used in the existing systems are expensive and add up to the already high cost of installation and maintenance.

7. The current system always faces problems such as delay in warning people about bad weather and sudden changes in the forecast.

3. PROPOSED SYSTEM

The system proposed is an advanced solution for weather monitoring that uses IoT to make its real time data easily accessible over a very wide range. The system deals with monitoring weather and climate changes like

1.Temperature, humidity by using the DHT11 sensor,

2.Wind speed using an Anemometer,

3. Light intensity using an LDR,

4. UV radiation using a GY8511 solar sensor,

5. Carbon monoxide levels in the air using MQ7,

6. Soil moisture using Hygrometer

7. Ultrasonic sensor for rain water level,

8. Raindrop sensor for detecting rainfall or snow fall.

3.1 Feature and advantages of the proposed sytem

1. Our proposed 'Smart weather monitoring system' unlike conventional weather monitoring instruments is very small and compact allowing it to be installed easily on rooftops.

2. It is light and portable; this advantage allows us to easily carry it to remote location for installation. Due to its design it can be easily be carried by a weather balloon to measure atmospheric changes at high altitudes.

3. The power requirements for our system (sensors and boards) is much less compared to the existing instruments in the market hence enabling us to use solar cells as power supply. This not only cuts down on cost but allows us to leave the monitoring system in remote, areas where power is not easily available, for long periods of time. Addition of solar panels also helps our design be eco-friendly.

4. The sensors used in our product are much cheaper compared to the ones that are used in the existing weather monitoring systems making our design more cost effective.

5. These sensors send the data to a web page and the sensor data is plotted as graphical statistics. The data uploaded to the web page can easily be accessible from anywhere in the world. The data gathered in these web pages can also be used for future references. Unlike the existing system where data has to be physically transferred.

6. Due to the presence of fewer moving parts less amount of maintenance will be needed cutting down on maintenance charges.

7. The product even consists of an app that sends notifications as an effective alert system to warn people about sudden and drastic weather changes. This works as an efficient warning system for bad weather and storms.

8. For predicting more complex weather forecast that can't be done by sensors alone we use an API with the help of a Raspberry pi that analyses the data collected by the sensors and predicts an accurate outcome. This API can be used to access the data anywhere and at any time with relative ease and can also be used to store data for future use.

4. SYSTEM ARCHITECTURE

The implemented system consists of an Arduino Uno which is used as a main processing unit for the entire system and all the sensor and devices can be connected with the microcontroller. The sensors can be operated by the microcontroller to retrieve the data from them and it processes the analysis with the sensor data. The processed data can be uploaded and stored in a website to function as a data base using nodemcu and Ubidots.

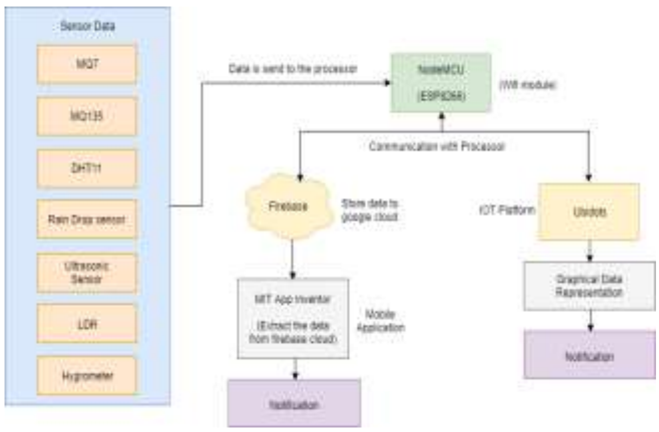

Fig -1: System Architecture

4.1 Arduino UNO

Fig – 2: Arduino UNO development board

It is an open-source physical computing platform based on a simple micro-controller board, and a development environment for writing software for the board. Arduino can be used to develop interactive objects, taking inputs from a variety of switches and or sensors, controlling a variety of lights, motors, and other physical outputs.

1. Microcontroller: Microchip ATmega328P
2. Operating Voltage: 5 Volt
3. Input Voltage: 7 to 20 Volts
4. Digital I/O Pins: 14 (of which 6 provide PWM output)
5. Analog Input Pins: 6
6. DC Current per I/O Pin: 20 mA
7. DC Current for 3.3V Pin: 50 mA
8. Flash Memory: 32 KB of which 0.5 KB used by bootloader
9. SRAM: 2 KB
10. EEPROM: 1 KB
11. Clock Speed: 16 MHz
12. Length: 68.6 mm
13. Width: 53.4 mm
14. Weight: 25 g

4.2 NodeMCU

Fig – 3: NodeMCU

NodeMCU is an open source IoT platform. It includes firmware which runs on the ESP8266 Wi-Fi SoC from Espressif Systems, and hardware which is based on the ESP-12 module.

1. Type: single board microcontroller
2. Operating system: XTOS
3. CPU: ESP8266
4. Memory: 128 kbytes
5. Storage: 4Mbytes
6. Power: USB

4.3 LDR Light-Dependent Resistor

Fig – 4: LDR

Light intensity is measured using an LDR. An LDR is a component that has a (variable) resistance that changes with the light intensity that falls upon it. This lets them to be used in light sensing circuits. A light dependent resistor (LDR) is a light-controlled inconstant resistor. The resistance of this decreases with increasing incident light intensity; in other words, it exhibits photoconductivity.

4.4 CO Sensor

Fig – 5: MQ - 7

Carbon Monoxide (CO) sensor, suitable for sening CO concentrations in the air. The MQ-7 can sense CO-gas concentrations anywhere from 20 to 2000ppm.This sensor has a high sensitivity and fast reaction time. The sensor's output is an anlog resistance.

Table -1: MQ – 7 Specification

symbol	parameter	Technical condition
Tao	Using temperature	-20℃-50℃
Tas	Storage temperature	-20℃-50℃
RH	Relative humidity	Less than 95%RH
O2	Oxygen concentration	21%(stand condition) the oxygen concentration can affect the sensitivity characteristic

1. Standard working Temperature: 20℃±2℃
2. Relative humidity: 65%±5%
3. RL: 10K Ω ±5%
4. Detecting range:20ppm-2000ppm carbon monoxide

4.5 DHT11

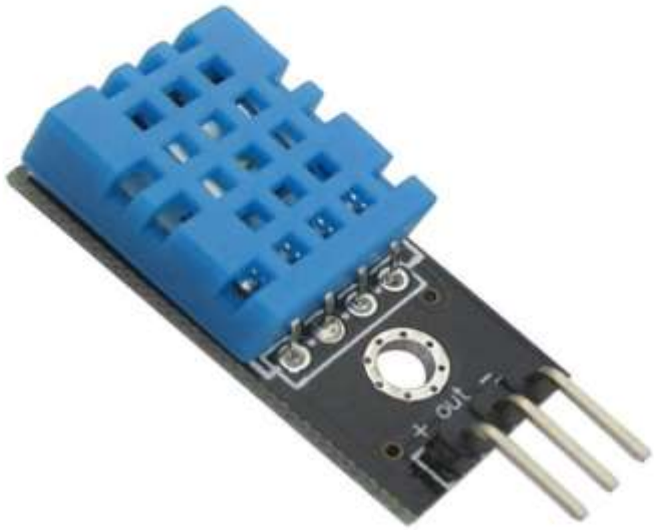

Fig – 6: DHT11

The DHT11 is a basic, ultra-low-cost digital temperature and humidity sensor. It uses a capacitive humidity instrument and a thermistor to measure the surrounding air, and spits out a digital signal on the data pin (no analog input pins needed).

1. Temperature range: 0℃-50℃ / ±2℃
2. Humidity Range: 20℃-80℃ / ±2℃
3. Sampling rate: 1Hz (one reading every second)
4. Body size: 15.5mm*12mm*5.5mm
5. Operating voltage: 3-5V
6. Max current during measure: 2.5mA

4.6 ML8511

Fig – 7: ML8511

ML8511 module is an informal to use ultraviolet light sensor. The ML8511 Sensor works by outputting an analog signal in relation to the amount of detected UV light. This breakout can be very handy in creating devices that warn the user of sunburn or detect the UV index as it communicates to weather conditions.

1. Supply Voltage: DC 5V
2. Operating Temperature: -20～70℃
3. Sensitivity Region：UV-A and UV-B
4. Sensitivity Wave Length: 280-390nm
5. Module Size: 30 x 22mm

4.7 Anemometer

Fig – 8: Anemometer

An anemometer is a device used for determining the speed of wind, and is also a common weather station instrument.

1. Style: three cups
2. Material: aluminium alloy
3. The mode of its output signal：0-5V(Voltage signal)
4. supply voltage: DC 9-24V
5. Power consumption：Voltage MAX≤0.3W
6. Start wind speed：0.4-0.8m/s
7. resolution：0.1m/s
8. Effective wind speed measurement range：0-30m/s
9. System error：±3%
10. Transmission distance：More than 1000m
11. Transmission medium：Cable transmission
12. Connection mode：Three wire system
13. Working temperature：-40℃~80℃
14. Working humidity: 35%～85%

4.8 Dark Sky.net

Dark Sky is an open source Internet of Things (IOT) application and API to store and retrieve data from things using the HTTP protocol over the Internet or via a Local Area Network. We interface it with the help of a Raspberry pi. Raspberry Pi:

Fig – 9: Raspberry pi

The Raspberry Pi is a low cost, credit-card sized computer that pads into a computer monitor or TV, and uses a standard keyboard and mouse.

4.9 Android App

This product also consists of an app which is developed using the MIT app inventor. The main pupose of this app is to provide notifications on weather updates and to act as warning system in case of bad weather. The app will obtain the neessary information through the existing database.

5. ANALYSIS

5.1 Graphical representation

Fig – 10: Ubidots

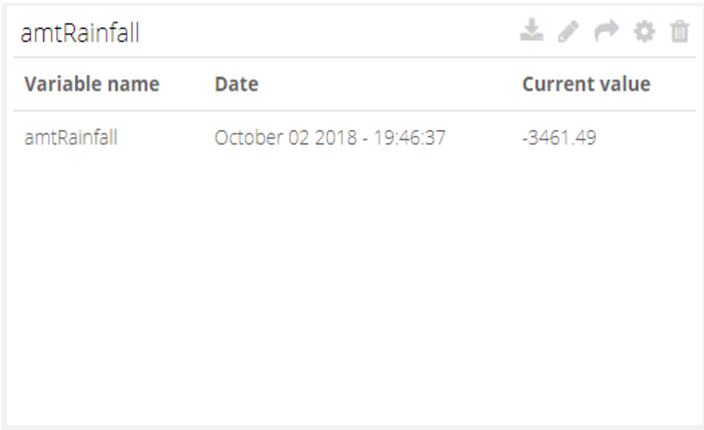

Fig – 11: Amount of rainfall

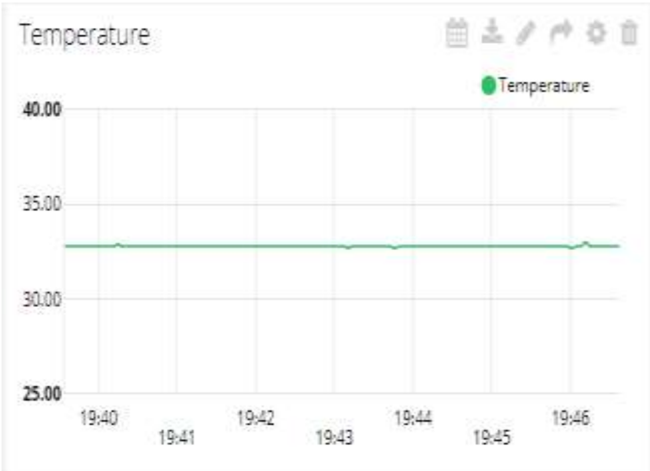

Fig – 12: Temperature

Fig – 13: Humidity

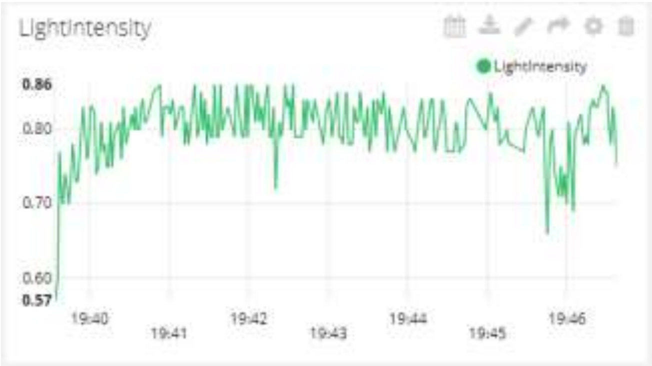

Fig – 12: Light Intensity

6. IMPLEMENTATION

The proposed system can be implimented in a 4- tier model with the functions of each individual modules developed for monitoring the different weather parameters. The tier 1 is the environment, sensor devices in tier 2, sensor data acquisition and decision making in tier 3 and warning notification in tier 4. Here, the tier 1 provides information about the parameters under the region which is to be monitored. 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 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 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 levels. In this tier sensed data will be processed, stored in the cloud and accordingly the notification will be sent.

Based on the framework we have identified a suitable implementation model that consists of different sensor devices and other modules. In this implementation model we use a NodeMCU for sensing and storing the data in cloud. Inbuilt ADC and Wi-Fi module attaches the embedded device to internet. Sensors are connected to NodeMCU board for monitoring, ADC will convert the corresponding sensor reading to its digital value and from that value the corresponding environmental parameter will be evaluated.

6.1 Simulation Results

After detecting the data from different sensor devices, which are positioned in particular area of interest. The sensed data will be automatically sent to the web server, when a proper connection is recognized with sever device.
The web server page which will allow us to monitor and control the system. By entering IP address of server which is placed for monitoring we will get the equivalent web page. The web page gives the information of the weather parameters in that particular region, where the embedded monitoring system is placed.

7. CONCLUSIONS

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 it will record real time data. It can cooperate 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 entrenched system is presented with different models in this paper.
In the proposed architecture purposes 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 cooperative 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 manufacturing zones for pollution monitoring. To protect the public health from pollution, this model provides an efficient and low cost solution for unceasing monitoring of environment.

Additions that can be made to improve the system

1. Powering the device using solar panels.

2. Suspending the device from a weather balloon so that it

can be used to record atmospheric parameters at high altitudes and remote and inaccessible areas.

3. Use of a though exterior cover for the system that will act as a protective cover enabling the device to function in harsh weather conditions.

4. Designing a method to mount the weather monitoring device onto a buoyant platform like a buoy hence enabling the system to measures weather changes over the sea. This data can also be shared to Cargo ships and other nautical industries conducting operations within the area.

5. Using silica gel to prevent condensation on the exterior cover as condensation might affect the sensors readings.

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