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High Resolution Meteorological Parameters Measurement And Analysis For Quality Weather Forecasting

Shivdas P. Bankar
Electronics and Telecommunication Engineering N B Navale sinhgad college of Engineering Solapur, India

Prof. Sunita P. Sagat
Electronics and Telecommunication Engineering N B Navale sinhgad college of Engineering Solapur, India

ABSTRACT-
The paper aims at building a system which can be used universally at any scale for high resolution meteorological parameters measurement in a given environment with the evolution of miniaturized sensor devices coupled with wireless or wired technologies. This paper presents the real-time monitoring of different environmental parameters such as Air Pollution contents and weather parameters measurements using embedded FTP server technology at low-cost. ARM microcontroller based raspberry pi board with RJ-45 Ethernet port, Wi-Fi and sensors assembly can be used. Python can be use as software platform for operating system. The parameters include: concentrations of carbon dioxide and carbon monoxide such as temperature, humidity, pressure, altitude, wind speed and wind direction from ambient air as well as actual rainfall occurred were used for environmental parameter measurement. Acquired data from these sensors can be displayed on embedded FTP web server using internet protocol and Ethernet interface which can be seen anywhere and it can be saved in external drive. Along with this all collected data can be analyze by using different weather forecasting algorithms and record in view log for weather forecasting.

Keywords- weather station, raspberry pi 3, wind speed(WS),Wind directon(WD), temperature, humidity, rain gauge.

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I. INTRODUCTION

Continuous changing of climate and weather conditions has been studied for a centuries. Huge importance of climate influence to human life motivated development of whole scientific areas devoted to climate and weather observation. In the beginning, simple and inaccurate instruments were used, which were inadequate for easy reading and storing of measured parameters. Nowadays, automated observatories and weather stations around the world collect environmental parameters continuously. These measured parameters are not useful if are not transferred in a fast and accurate manner to the primary users. Therefore, transfer and processing of measurement data is very important aspect of modern measurements. It is now common to use the sophisticated instruments that measures environmental parameters and transfer it to some destination. Such instruments are known as weather stations. Transfer of measured data can be accomplished by a number of means: direct wired link, satellite link, WiFi link, GSM/GPRS link, etc.

Collected and analyzed environmental parameters have a very wide utilization. The most common objective, which is widest used, is a weather forecast. However, there are numerous different purposes of these parameters, such as studying of global climate change, real-time micro location data acquisition, animal and plant protection and monitoring, etc. Next to scientific and commercial applications, weather stations can be used for educational purposes.

Air pollution means presence of high concentrations of harmful gases such as dust, smoke. Inhaling these gases can increase the chances of health problems. In fact, dust when inhaled can cause breathing problems, damage lung tissue, and boost up existing health problems. Greenhouse gases trap heat and make the earth warmer. Human activities are responsible for almost all of the increases in greenhouse gases. Therefore, every federal government has stringent regulations

which require prevention and reduction of emission levels. In our project, the major air pollutants like CO2, smoke, CO is monitored using sensors and values obtained are processed using Raspberry Pi. Then the data values are sent to an IP address and can be monitored from anywhere from logging into the IP address

Internet of Things (IOT)

Internet of Things (IoTs): The Internet of Things (IoTs) can be described as connecting everyday objects like smart-phones, Internet TVs, sensors and actuators to the Internet where the devices are intelligently linked together enabling new forms of communication between things and people, and between things themselves. Building IoTs has advanced significantly in the last couple of years since it has added a new dimension to the world of information and communication technologies. It is expected that the number of devices connected to the Internet will accumulate from 100.4 million in 2011 to 2.1 billion by the year 2021, growing at a rate of 36% per year. In the year 2011, 80% machine to machine (M2M) connections were made over mobile networks such as 2G and 3G and it is predicted that by 2021, this ratio will increase to 93% since the cost related with M2M over mobile networks are generally cheaper than fixed networks. Now anyone, from anytime and anywhere can have connectivity for anything and it is expected that these connections will extend and create an entirely advanced dynamic network of IoTs. The development of the Internet of Things will revolutionize a number of sectors, from automation, transportation, energy, healthcare, financial services to nanotechnology. IoTs technology can also be applied to create a new concept and wide development space for smart homes to provide intelligence, comfort and to improve the quality of life.

By using the sensor for carbon dioxide, carbon monoxide, smoke we will get know the air pollution over the earth and by using sensor like air temperature, humidity, atmospheric pressure, rain and we will know the weather forecasting for current day as well as over years too.

In this project there is scope for quality weather data measurement and the forecasting according to the data which will be measured by the system. The quality weather forecasting will give better prediction and betterment of decisions on the weather which helps people who really dependent on weather like Agro, Food, Mechanical industries and many more. In Agriculture field if the weather prediction is correct it will help farmers to grow crops and maintain them well and they will decide their own schedules of farming based on the weather forecasting system

II. LITERATURE REVIEW

Phala, kgoputjo et al [2] presented an air quality monitoring system (AQMS) which is based on the IEEE/ISO/IEC 21451 standard.Concentrations of CO, CO2, SO2 and NO2, were measured using electrochemical and infrared sensors. Results are saved in the data server.

Xing Liu, Orlando [4] presented a comparative study on smart sensors, objects, devices and things in Internet of Things. The authors have also explained the definition and concepts of IoT in various different ways. The differences and similarities between the smart objects, smart things in IoT are presented in tabular form.

Marinov, Marin B. et al [3] monitors environmental parameters with amperometric sensors and gas sensors (infrared) using the PIC18F87K22 microcontroller. Sensor nodes are set up in different areas for real time monitoring of environment. The results are displayed on the city map.

Baralis, Elena et al [11] proposes a business intelligence engine (APA). The system is designed to aware the public International Conference on Computing, Communication and Automation (ICCCA2017) about the quality of air being affected by different factors like pollutants, toxic gases etc. Analysis of air pollution from different perspectives like meteorological data, pollutants and traffic data using APA is done. The system helps the people to realize their activities impact on deteriorating air quality.

Jha, Mukesh et al [7] presented a system for monitoring the environmental parameters, modeling and manipulating microclimate of urban areas. The system is implemented for the adaption of efficient urban infrastructure after analyzing the urban micro-climate.

Shete., R. and Agrawal S. [6] provides the framework for monitoring the city environment. Low cost Raspberry pi is used for implanting the system. Parameters like carbon monoxide, carbon dioxide, temperature and pressure are measured but no emphasis is given on particulate matter which left the environment monitoring incomplete.

Mitar simic, Goran M. et al [16] presented a system for measurement and acquisition of data of water and air quality parameters and results are shown on IBM Watson IoT platform. The system is battery powered with solar panel based charger unit.

Chiwewe, Tapiwa M., and Jeofrey Ditsela [17] collected air quality data from different cities of

South Africa. Machine learning technique was applied to the data and prediction models were generated for ground level ozone.

Ruchi Mittal and Bhatia [5] propose a system in which they detect irregular patterns of sensory data with respect to time and space. They design a system which continuously queries and monitors sensor data to detect any deviations from the norm. This is essential in detecting a faulty sensor node and ensuring it can be quickly replaced. This system is especially helpful when detecting environmental activity like forest re. In order to achieve desired results, Data preprocessing and sensor data clustering is used. In data preprocessing, the sensor data is cleaned by putting in missing values and removing any unwanted data. Mittal and Bhatia analyzed this data cluster by plotting data, comparing them against expected/predicted patterns and detect anomalies.

III. PROBLEM STATEMENT

Design and Implementation of high resolution meteorological parameters measurement system for quality weather forecasting using Raspberry Pi 3 to overcome existing problems in metrological measurements and forecasting systems

IV. METHODOLOGY

A. Hardware Requirements

1. Raspberry pi 3 modle
2. DHT11/22 sensor
3. MQ2 gas sensor
4. WS and WD sensor
5. Automatic rain gauge system
6. FTP server

B. Block Diagram

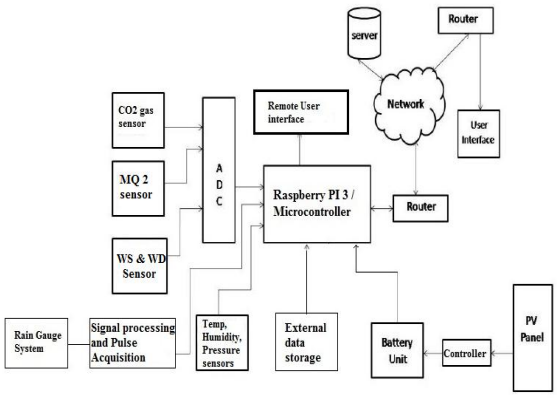

Figure1. Block diagram of proposed work

Figure1. shows proposed system block diagram for low cost high resolution metrological parameters measurement and analysis for weather forecasting. The main aim was to design a low cost, small size and useful solution for real-time weather monitoring and logging in school, colleges, research center. By using the sensor for carbon dioxide, carbon monoxide, ozone, smoke we will get know the air pollution over the earth and by using sensor like air temperature, humidity, atmospheric pressure, rain and we will know the weather forecasting for current day as well as over years too.

Collected meteorological data then send to a FTP database server as well as it stored in memory card (Pen drive). FTP database server help to access data from any remote location. Stored data then processed by different weather forecasting algorithms which will give better forecasting results.

C. Raspberry pi

In [4], Raspberry Pi 2 model B is a 85*56mm device with BCM2836 quad core (4 processors in one chip) ARMv7 processor. It is superior to the Raspberry Pi 1 Model B+ with its 900MHz speed compared to the 700MHz speed of the former one. It has 1 GB RAM which makes it the best choice for using it with the better browser performance. It has 4 USB ports and a full HDMI port. It is also designed effectively with the 40 pin GPIO. The other features include a combined 3.5mm audio jack and composite video with Video Core 4 3D graphics core. It has a separate camera as well as display interface. Raspberry Pi can be connected to a local area network through Ethernet cable or USB Wi-Fi adapter, and then it can be accessed by any client in the network. The SSH remote login or putty software can be used by which we can get access to Raspberry Pi by just putting its IP address. The raspberry pi is booted by micro SD card. The different operating systems which are supported by the Raspberry Pi are RASPBIAN, PIDORA, OPENELEC, RASPBMC, RISC OS and WINDOWS 10 as well. The system is using RASPBIAN operating system which is the massively popular OS also known as "distro". PYTHON is main programming language which is a highly flexible wrapping kind of language. In [5] it is given that the large set of libraries like GPIO, TIME makes the coding very easy and efficient. Its RAM makes it commendable choice to get the real time data processed and accessed faster than other microcontroller based systems.

D. Humidity and Temperature Sensor (DHT11)

DHT11 is interfaced with Raspberry Pi board at GPIO9 for humidity (in %) and temperature (in oC) measurement using single wire serial interface (SPI). DHT11 has resistive type humidity measurement component and negative temperature coefficient (NTC) temperature measurement

component. It gives calibrated digital output which Raspberry Pi can directly understand so no need to have analog to digital converter. This sensor needs 3-5.5V voltage supply and 0.5-2.5mA current supply, which can be given from Raspberry Pi board.

E. Pressure and Altitude Sensor (BMP180)

BMP180 is interfaced with Raspberry Pi board at SDA and SCL pin for atmospheric pressure (in Pa) and altitude (in m) from sea level measurement using I2C interface. It can also measure temperature. BMP180 works on the principle of piezo-resistive technology. BMP180 gives fully calibrated digital output so no need to have ADC. This sensor needs 1.8-3.6V supply voltage and 5μA supply current in standard mode, which can be given from Raspberry Pi board.

F. Rain Gauge

The rain gauge used for measuring rain. The rain gauges have mechanism of self-emptying tipping bucket type. It consists of funnel used collects and sends the precipitation into a small size seesaw. When a pre-set amount of precipitation falls or rain fall, the momentary contact will form, then collected water will release. One momentary contact closure caused 0.011" (0.2794mm) of rain. This can be recorded with a digital counter.

G. MQ2 sensor

The MQ-2 Gas sensor can detect or measure gasses like LPG, Alcohol, Propane, Hydrogen, CO and even methane. The module version of this sensor comes with a Digital Pin which makes this sensor to operate even without a microcontroller and that comes in handy when you are only trying to detect one particular gas. When it comes to measuring the gas in ppm the analog pin has to be used, the analog pin also TTL driven and works on 5V and hence can be used with most common microcontrollers.

Using an MQ sensor it detects a gas is very easy. You can either use the digital pin or the analog pin to accomplish this. Simply power the module with 5V and you should notice the power LED on the module to glow and when no gas it detected the output LED will remain turned off meaning the digital output pin will be 0V. Remember that these sensors have to be kept on for pre-heating time (mentioned in features above) before you can actually work with it. Now, introduce the sensor to the gas you want to detect and you should see the output LED to go high along with the digital pin, if not use the potentiometer until the output gets high. Now every time your sensor gets introduced to this gas at this particular concentration the digital pin will go high (5V) else will remain low (0V).

H. Wind Speed Sensor (Anemometer)

The most common kind of wind sensor is a kind of horizontal three-armed propeller, with a concave hemispherical cup on the end of each arm.

The air pressure on the inside of the cup, which help push the cups and due this it start to revolve at more than two-fifth the speed of the wind. These cups are fixed with arm on one point.

Wind speed sensor is used for measuring wind speed by closing magnet switch. Wind speed sensor is used for measuring wind speed by closing magnet switch. Due to switch close to per second causes 1.492 MPH or 2.4 km/s wind speed [18].

I. Wind Direction Sensor

The wind direction sensor has eight switches. Every switch is joined with different values of resistor.
Two switches may close at the time due to the magnet.

The voltage divider is formed by using external resistor, which producing a different output voltage for each switch. By using ADC we can measure the output voltage. Eight different resistor values give sixteen possible positions. [18]

J. FTP Server

An FTP server is a computer which has a file transfer protocol (FTP) address and is dedicated to receiving an FTP connection. An FTP server needs a TCP/IP network for functioning and is dependent on usage of dedicated servers with one or more FTP clients. In order to ensure that connections can be established at all times from the clients, an FTP server is usually switched on. An FTP server is an important component in FTP architecture and helps in exchanging of files over internet. An FTP server is also known as an FTP site

V. CONCLUSION

The proposed system will provide low cost, low power, compact and highly accurate system for monitoring the environment with the dedicated sensors remotely from any place in this world. A perfect tradeoff between accuracy and cost will be achieved by making use of single board minicomputer Raspberry pi and appropriate sensors leading to a well grounded system. The ubiquitous availability of dynamic datasheets on the dashboard and the time to time graphical representation can help in planning the control measures against increasing pollution levels and create awareness among the people.

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