An IoT application for environmental monitoring and control using Raspberry-Pi

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***Abstract*—Raspberry Pi hardware board is an economical Internet of Things (IoT) hardware platform that can be used for wide variety of applications. This paper discusses the hardware, software platforms and implementation details of an IoT application for environmental monitoring and control using Raspberry PI 3 Model B. The *DHT11* sensor is used to monitor temperature and humidity to further control the air conditioning system. The *FC-37* sensor is used to detect the rainfall and further control the sprinkling system. The *MQ135* sensor is used to detect the presence of hazardous gasses in the environment. Django web technology platform is used to design a dashboard for monitoring and controlling the things. MySQL database is used to log the sensor data and Fusion charts are used to display the trends in graphical form.**

Keywords-IoT, Internet of Things, Embedded Systems, Raspberry PI, Sensors, Control.

I. Introduction

IoT is a technology that helps to establish internet connectivity between people and a wide variety of devices. IoT enables to monitor and control several parameters, take decisions, and automate the control system. The major advantages of IoT are continuous data logging, tracking the status of environment or the parameters under consideration, saving a lot of time and money. Raspberry Pi [1] is a popular 64-bit embedded hardware platform that is most suitable for IoT applications. This paper makes use of Raspberry Pi 3 model B hardware board along with few sensors in order to monitor and control environmental parameters and devices. The parameters that are monitored are temperature, humidity, rainfall, and hazardous gasses. The main goal of this work is to design an IoT for continuous monitoring and control of environmental parameters viz., temperature & humidity, hazardous gases, and rain.

II. Related Work

Anwaar and Shah[2] compared raspberry pi with other technological inventions like Smart Phone, tablet computer, smart TV, and Laptop. Their outcomes demonstrate that raspberry pi consumes less power and computation jobs can be accomplished in a better vitally effective manner. In this work he used hardware devices like tablet Pc, laptop, smart TV and raspberry Pi. Here energy efficiency is calculated in kilojoules per hour. The authors have compared the power consumptions of all the computing devices. They observed that the desktop consumes 82 watts, a laptop, a smart phone consumes 50 and 5 watts respectively. Whereas a raspberry pi system only consumed 2.25 watts. Therefore raspberry pi is more energy efficient than the other computing devices.

Zhao et al.[3], explored the application of raspberry pi system as a server along with other laptops in the same network. They have established client server communication using Wi-Fi, ZigBee protocols within localhost for remote file sharing. Samba is an open source software used in this project for file and print services. Raspbian Operating Systems was used for raspberry pi project development. Varma et al. used Rabbit processor as an embedded web server and also implemented a Denial of Service attack detection mechanism [4]. Sandeep et al.[5]have proposed this automation system to control machines in laboratories with high mobility and security.Electronic devices were interfaced to the raspberry pi and were remotely controlled through weaved fabric cloud platform. The General Purpose Input Output (GPIO) pins of the raspberry pi board were controlled using Webiopi software. The raspberry pi was interfaced to Digiduino board for amplification, in order to connect the relay switches to control the external devices.

Ibrahim et al.[6] developed a low-cost environmental monitoring system by making use of the raspberry pi computing board. Sensors used in this work are temperature sensor TMP36, Humidity DHT22, CO concentration using MQ-7, Earthquake thin-film-piezoelectric sensor LDT0028K. Pavithra and Balakrishnan[7] proposed an efficient system for monitoring and controlling the home appliances via World Wide Web. In this work communication takes place through internet gateway by using protocols like Zigbee, WiFi etc. In addition to that fire alarm system has been established. Home appliances used are lights, and fan. Sensors used are IR sensor for lights, PIR sensor for fans and Fire detection sensor for fire. These sensors are connected and interfaced through raspberry pi and can be controlled through our mobile phones. WiFi provides the medium for configuration which can be configured to make security services. Different web pages are created for different rooms to access appliances separately. One of the advantages is that this system can be monitored and controlled from any OS in mobile phones.

Daniel et al.[8]proposed a system to control the temperature in anautomated and efficient way using Fuzzy logic. Here prototype consumes data from sensors and IoT platform. The main idea is to get temperature on outdoor and basing on that system is designed to control indoor temperature using IoT. Hardware components used in this work are a TMP36 temperature sensor, MCP3008 analogic-to-digital converter, 2 yellow LEDs, 2 red LEDs, and 1 RGB LED,Several resistors.Chowdhury et al.[9]designed a raspberry pi based visitor notification system. They have interfaced a camera to take a picture of the visitor and notify through twitter. Wi-Fi communication was used to interface the camera and Infra-Red (IR) sensor for human presence sensing. Raspberry pi was configured as an Internet server to remotely communicate the information to anywhere the user wants. Street lights were automated through IoT technology using raspberry pi by Leccese et al. in [10]. Aksh et al. [11] designed a raspberry pi project to control wheel chair through IoT using WebIOpi framework. Ray [12] has done a similar work to monitor MISSENARD index using Arduino hardware platform and ThingSpeak and Plotly cloud software platform. Other interesting applications of Raspberry pi include controlling a car remotely [13], home automation [14]. Security is one the major concern in IoT projects. Intrusion Detection Systems (IDS) and Firewalls [15][16][17][18][19][20]takes the front seat in protecting the network perimeter along with host based security tools.

III.ENVIRONMENTAL MONITORING AND CONTROL USING RASPBERRY PI

This work proposes a smart environmental parameters monitoring and control system using Raspberry Pi 3 Model B. Three different sensors are used to monitor the temperature and humidity, rainfall, and hazardous gasses. The block diagram is as shown in Fig.1. A picture of the project hardware is shown in Fig.2.

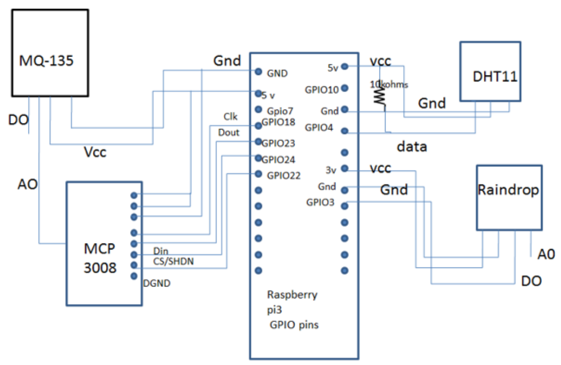


Fig.1 The proposed system block diagram

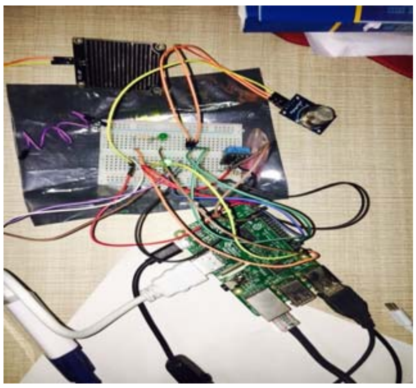


Fig.2 Picture of the hardware implementation

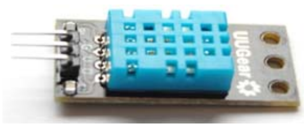


Fig.3 DHT11 Sensor

Fig.4 FC-37 Sensor

Fig.5 MQ135 Sensor

A. *About the sensors used in the system*

DHT-11 is a temperature and humidity sensor, shown in Fig.3. The advantage of this sensor is it is highly reliable, low price, good quality, faster response time, and inference free design. This sensor can measure temperatures ranging from 0 to 50^{o}C with an error of plus or minus 2^{o}C. The range of humidity measure that DHT11 can support is 20 to 90% RH with an allowable error of 5%. It can directly provide a digital output with its own serial communication protocol. It can operate at a low supply voltage of minimum 3V up to 5.5V. It has only three pins, for Vcc, data, and ground. It uses Negative Temperature Coefficient (NTC) based temperature sensing component, and moisture substrate based humidity sensing component.

FC-37 is a raindrop sensor, shown in Fig.4. It contains two parts, one board is the electronic board and the other one is the rain drop collecting board. It has both analog as well as digital output. The digital output is one bit binary to indicate if there is rain or not. It operates on a 5V supply. The digital output remains at a high level when the surface is dry and output goes to a low level when the surface is wet.

MQ135 is a gas sensor (Fig.5) that can detect harmful gasses including smoke, Sulphide, Ammonia, Benzene, Carbon dioxide, and alcohol. MQ135 indicates the type of gas in the form of an analog signal and an Analog-to-Digital converter MCP3008 is used to convert it to digital and interface to the raspberry pi.

B. *Software platform*

Raspbian Operating system is used along with apache web server. Django Python web framework is used for the web interface development. The advantage of Django is that it is a fast, secure and scalable platform. Only free and open source software are used in the design of the proposed system. MySQL is used for the database interface to the system. Fusion charts are used in visualizing the sensor data in the form of graphs. Fig.6 shows the installation steps in the raspberry pi.

Step 1. Updating and Cleaning your Raspberry Pi

sudo apt-get update -y
sudo apt-get upgrade -y
sudo apt-get autoremove

Step 2. Install Python MySQLDB

sudo apt-get install python-mysqldb –y

Step 3. Install LAMP Server

sudo apt-get install apache2 –y
sudo apt-get install mysql-server mysql-client –y
sudo service apache2 restart

Step 4: Install Python Setup tools

sudo apt-get install python-setuptools -y
sudo apt-get install python-setuptools -y

Step 5. Make sure you have PIP installed

wget https://bootstrap.pypa.io/get-pip.py
sudo python get-pip.py
sudo rm -rf get-pip.py

Step 6: Install Django

sudo pip install Django
sudo pip install Django

Step 7: Creating our application

django-admin startproject DjangoProject
cd DjangoProject

Step 9: Migrating DB and Running App

Migrate the DB and starting our application. We have to use our own Raspberry Pi IP address

python manage.py migrate
python manage.py runserver 192.168.5.207:8000

Step 10: Install Apache Web Server

sudo apt-get install apache2 –y

Step 11: Install Adafruit Python DHT11 sensor library

Fig.6 Installation steps of software

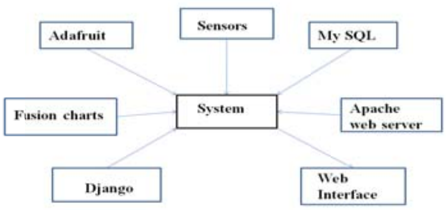


Fig.7 Software Block Diagram

C. Algorithm

The algorithm that is developed for an IoT application for environmental monitoring and control is as shown in Algorithm.1.

Algorithm 1

Step1: start

Step2: declare variables humidity, temperature, gas,gas1, state, rain, sprinkler, AC.

Step 3: loop

Step 4: reads humidity and temperature values from dht11

Step 5: if temperature > 40 ac =on
else ac = off

Step 6: reads state from fc-37
Step 7: if state==1 rain= rainfall detected and sprinkler = off
else rain= not detected sprinkler= on
Step 8: reads gas value from mq-135
Step 9: if gas <180 :
gas1="normal gas "
else if gas < 400 and gas> 380 :
gas1= "co2 "
else if gas < 440 and gas > 400 :
gas1= "benzene "
else if gas < 700 and gas > 680 :
gas1= "alcohol "
Step 10: return temperature, humidity, rain, ac, sprinkler, gas, gas1 to webpage
Step 11: end loop
Step 12: stop

IV. RESULTS

In the Login page authentication is done. If the user is validated, the main page will be displayed, otherwise it will redirect to login page saying invalid user. The screen shot of login page is shown in Fig.8 All sensor results are displayed on this page. Temperature, humidity and gas concentration values are shown in Fig.9. The web page is dynamic and the refresh cycle is set to few seconds that can be programmed as required.

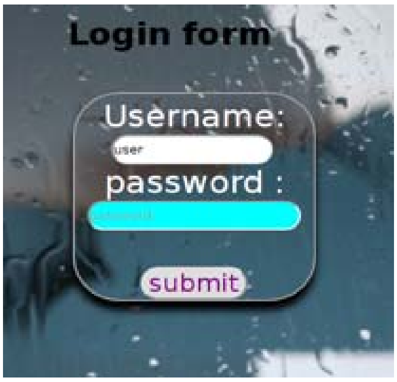


Fig. 8 Login Page for authentication

The code snippet for logging the sensor data using the MySQL data base is shown below.

```
fromdjango.db import models
fromdatetime import datetime
class Weather(models.Model):
temperature = models.DecimalField(max_digits=5,decimal_places=2)
humidity = models.DecimalField(max_digits=5,decimal_places=2)
rainfall = models.CharField(max_length=20)
gas= models.CharField(max_length=20)
date = models.DateTimeField(default=datetime.now,blank=True)
```

A sample data base is shown in Fig.10. A sample graph generated by fusion chart is shown in Fig.11.

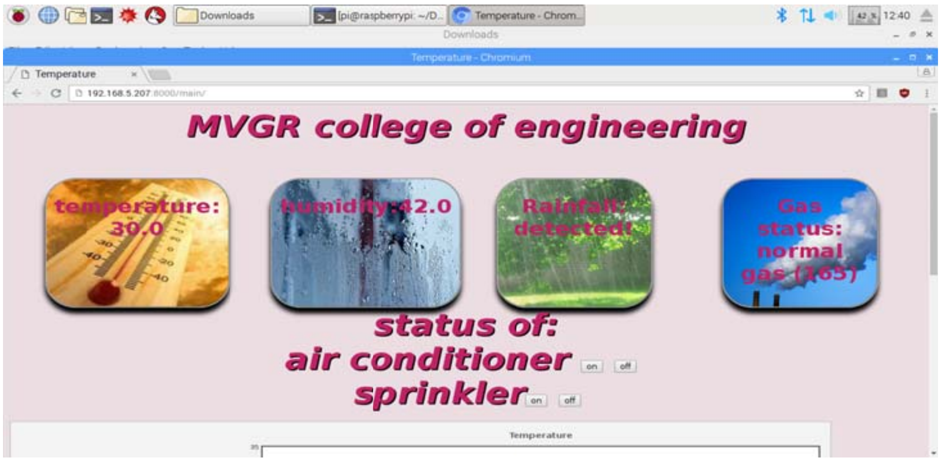
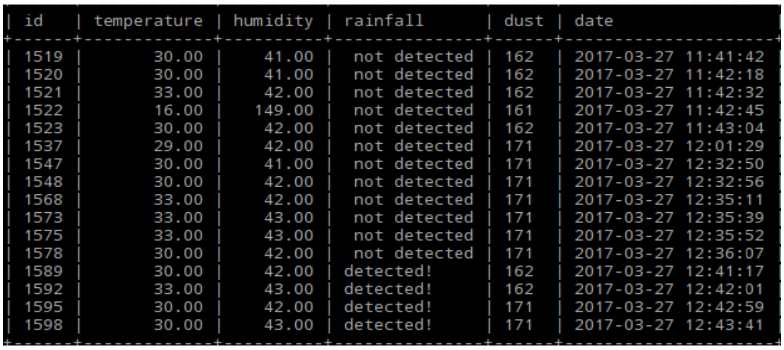


Fig. 9 Web Interface



id	temperature	humidity	rainfall	dust	date
1519	30.00	41.00	not detected	162	2017-03-27 11:41:42
1520	30.00	41.00	not detected	162	2017-03-27 11:42:18
1521	33.00	42.00	not detected	162	2017-03-27 11:42:32
1522	16.00	149.00	not detected	161	2017-03-27 11:42:45
1523	30.00	42.00	not detected	162	2017-03-27 11:43:04
1537	29.00	42.00	not detected	171	2017-03-27 12:01:29
1547	30.00	41.00	not detected	171	2017-03-27 12:32:50
1548	30.00	42.00	not detected	171	2017-03-27 12:32:56
1568	33.00	42.00	not detected	171	2017-03-27 12:35:11
1573	33.00	43.00	not detected	171	2017-03-27 12:35:39
1575	33.00	43.00	not detected	171	2017-03-27 12:35:52
1578	30.00	42.00	not detected	171	2017-03-27 12:36:07
1589	30.00	42.00	detected!	162	2017-03-27 12:41:17
1592	33.00	43.00	detected!	162	2017-03-27 12:42:01
1595	30.00	42.00	detected!	171	2017-03-27 12:42:59
1598	30.00	43.00	detected!	171	2017-03-27 12:43:41

Fig.10 Sensor Database

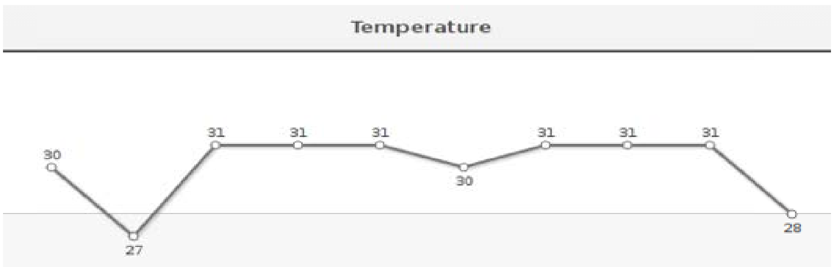


Fig. 11 Output of the Fusion Chart for temperature data

V. Conclusion

The proposed IoT application for environmental monitoring and control using Raspberry PI provides an economical user-friendly web interface for monitoring and controlling IoT sensors. It is an automated, scalable, and cheaper solution. We can see the results from anywhere in the world through the web interface. Manual as well as automated control of output devices viz., sprinklers and the air conditioner is implemented. In this work all results are stored in a database which can be viewed through charts (Fusion Charts). For that we used a framework called Fusion Charts which can be downloaded from the official Website. Fusion Charts enables us to get the data from the database with few lines of code and directly integrates with the required chart. Chart look and feel can be changed by simply selecting the theme. Further work is needed to implement this on the android mobile platform.

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