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Agricultural Environment Monitoring Using Internet of Things and Wireless Sensor Networks

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Abstract

Agriculture is the main food production system of a country. Within the decades there are many research work has been demonstrated to improve the cultivation of agriculture using new technology. In this paper, an agricultural environment monitoring system is described using Internet of Things, open source platform Raspberry Pi and Wireless Sensor Network. In this system, the Wireless Sensors collect the data of various environmental parameters such as temperature, humidity, soil moisture etc. and send the collected data to Raspberry Pi. The Raspberry Pi stores the data in a database of a web server. The data can be monitored from anywhere of the world. A client side website is developed to show the data. If the collected environmental data reaches in a threshold condition, a gmail notification is sent to the user as a warning. In this paper, overall description of the system architecture, used hardware and software components are described in details.

Keywords: Raspberry Pi, Wireless Sensor Network, Environmental monitoring, Internet of Things, Agriculture.

1. INTRODUCTION

Within the decades the use of internet has drastically changed from mainframe computers to smart phones. At the turn of ages, a new concept came across which is called Internet of Things (IoT).Internet of Things(IoT) means interconnected devices of a physical network which can be used to control or sense any device in the network that is used in indoor or outdoor for sharing data and resources. Sensors are used to convert physical quantity into numerical data. The network which is constructed with various wireless sensors is called Wireless Sensor Network (WSN). In recent days, the use of IoT and WSN is emerging widely to solve different problems to ease the day to day life of human. Furthermore, the production of food is a very important factor for survival of human.

Much research has been taken place for improvement of the food production system. Hwang, Jeonghwan (2010) presented a system for environment monitoring for agriculture that collects environmental and soil information of the outdoorthrough WSN-based sensors, image information through CCTVs, and location information using GPS modules. It processes the data using a MSP430 MCU and transmits them to relay nodes and gateways, using a CC2420 RF chip.

Some have presented system to do future prediction of environment. Gaddam,Anuroop (2014) addressed a system of drought monitoring using Wireless Sensor Networks (WSN). It can predict drought situation using collected soil moisture data.

Radio-frequency identification (**RFID**) uses electromagnetic fields to automatically identify and track tags attached to objects. The tags contain electronically stored information. Passive tags collect energy from a nearby **RFID** reader's interrogating radio waves.

RFID technology is also used to in some researches to monitor the environment. As like, Zhao, Ji-Chun (2010), they proposed a structure of agriculture greenhouse production environment measurement and control system based on wired and wireless sensors using RFID technology.
Vasilenko, M. Ulman (2015) presented a concept of horticulture ambient intelligence system that determines watering efficiency in agricultural and horticultural activities.
Sahu (2015),Tarange (2015), Agrawal (2015) proposed an automatic irrigation and controlling system using Raspberry Pi and sensors to optimize the use of water.
Sheikh Ferdoush and Xinrong Li (2014) presented a generalized design of environment monitoring system using WSN technology, Raspberry pi and Arduino.
Lazarescu, Mihai T (2013) emphasized on designing WSN platforms and sensor node design for long term environment monitoring. They gave importance to design low cost system to monitor environment. TongKe, Fan (2013) found integration of cloud computing, RFID technology and IoT useful to create a smart agriculture environment.

2. OVERALL SYSTEM ARCHITECTURE

In Figure 1.the block diagram of the proposed system architecture is shown. The sensor collects data from the environment. The Raspberry Pi processes the collected data and stores it in a database of a web server. The users can access to the data through a web application through browser which has an internet connection in it. The digital sensor can directly communicate with the Raspberry Pi 3 through its GPI/O pins.But Raspberry Pi does not have analogue pins. So, it cannot communicate with the analogue sensors directly. In that case, an analogue to digital converter is used to get digital data from analogue sensors.

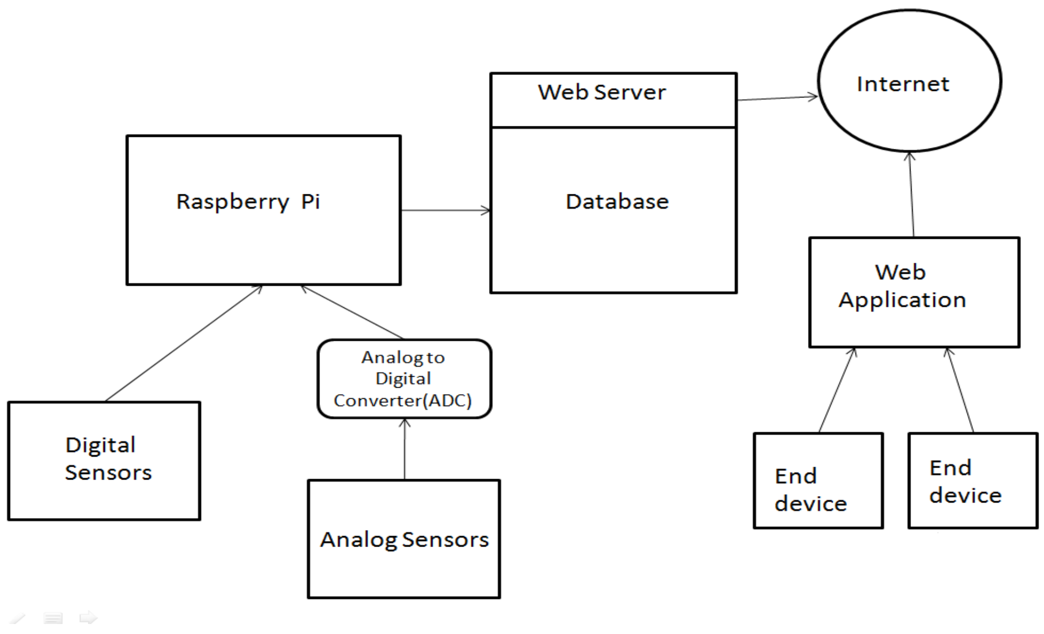

Figure 1. Block diagram of the proposed system architecture

3. HARDWARE PROTOTYPE

3.1. Raspberry Pi 3 Model B

The main system is embedded in Raspberry Pi 3 Model B.Raspberry Pi is a credit card size microcomputer. The Raspberry Pi 3 is the third generation Raspberry Pi.It has 1.2GHz 64-bit quadcore ARMv8 CPU, 802.11n Wireless LAN, and Bluetooth 4.1Bluetooth Low Energy (BLE). It also has 1GB RAM,4 USB ports,40 GPIO pins, Full HDMI port, Ethernet port, combined 3.5mm audio jack and composite video, Camera interface (CSI), Display interface (DSI),Micro SD card slot (now push-pull rather than push-push)Video Core IV 3D graphics core. It requires 2 Amperes of current to power up and can tolerate up to 5Volts.

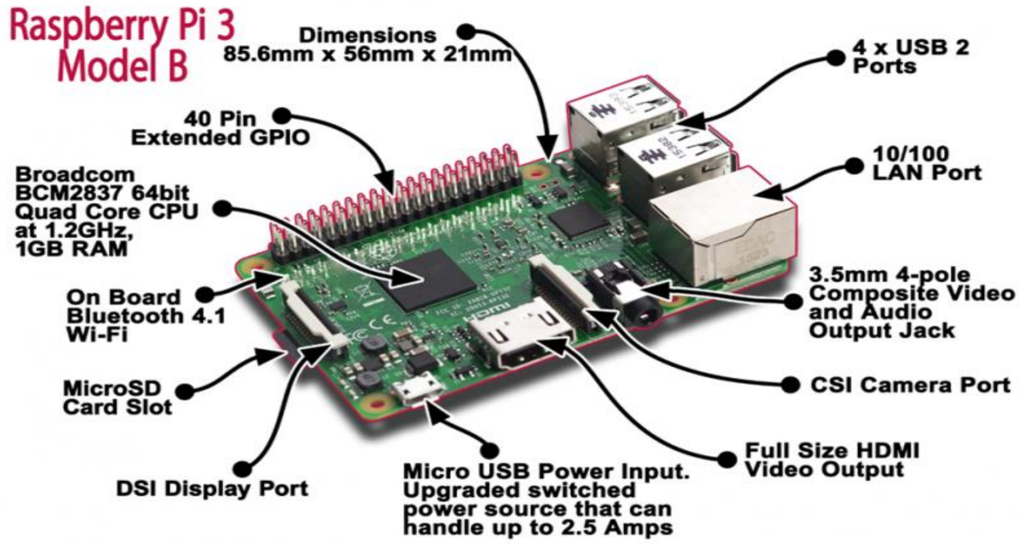

Figure 2. Raspberry Pi 3 Model B

3.2. Waterproof DS18B20 Digital Temperature Sensor

Waterproof DS18B20 Digital Temperature Sensor is used to measure temperature. It is used as a backup for readingtemperature in a wet condition for its waterproof facilities. It can tolerate maximum temperature 125°C but recommended temperature is 100°C.It requires max voltage 5V and min voltage 3.3V.

3.3. Grove Moisture Sensor

To measure soil moisture level, Grove moisture sensor is used.Soil moisture sensor based on soil resistivity measurement. It is very easy use. It has2.0cm width and 6.00cm long two probes which are inserted into the soil to measure the moisture level. The sensor works as with the specifications given in Table 1.

Table 1. Specifications of Grove moisture sensor

Item	Condition	Min	Typical	Max	Unit
Voltage	-	3.3	/	5.00	V
Current	-	0	/	35	mA
Output Value	Sensor in dry soil	0	-	300	/
	Sensor in humid soil	300	-	700	/
	Sensor in water	700	-	950	/

3.4. Analogue to Digital Converter

The ADS1115 is a great analogue to digital converter that iseasy to use with the Raspberry Pi using its I2C communication bus. The ADS1115 is a higher precision 16-bit ADC with 4channels. It has a programmable gain from 2/3x to 16x so it can amplify small signals and read them with higher precision. It is used in the system to convert the sensor’s analogue data to digital data.

4. PROPOSED SYSTEM AND IMPLEMENTATION

The main purpose of the proposed system is to monitor the environment of the agricultural field remotely. This is an application of Internet of Things. At first, Raspbian Jessie the latest operating system of Raspberry Pi, which is based on Debian Linux, is installed in the 8GB SD card of the Pi.As Raspberry Pi 3 supports Wireless LAN, it is connected wirelessly with the internet.

Raspbian Jessie directly boot with GUI interface which is an advantage of using it than earlier versions of Raspbian. The Raspbian is updated and upgraded to the newest features. The two sensors used for the system works with two different types of interfaces. The temperature sensor works with 1-wire interface and ADS1115 4-channel ADC which is needed for moisture sensor works with I2C interface. Both interfaces are enabled using the command in the terminal “sudoraspi-config”.

Grove Moisture sensor is an analog sensor it cannot give direct output to Raspberry Pi as Pi does not have any analog GPIO pins. In that case, it needs an Analog to Digital converterto give digital output. ADS1115 4-channel ADC works here. At first, the ADC is connected with the Raspberry Pi. In the secondstage, moisture sensor is connected with Pi and the SIG pin of the sensor is connected with one of the channel of the ADC.Wiring of the Raspberry Pi GPIO pins with the sensors and the ADC is shown in Figure 3.

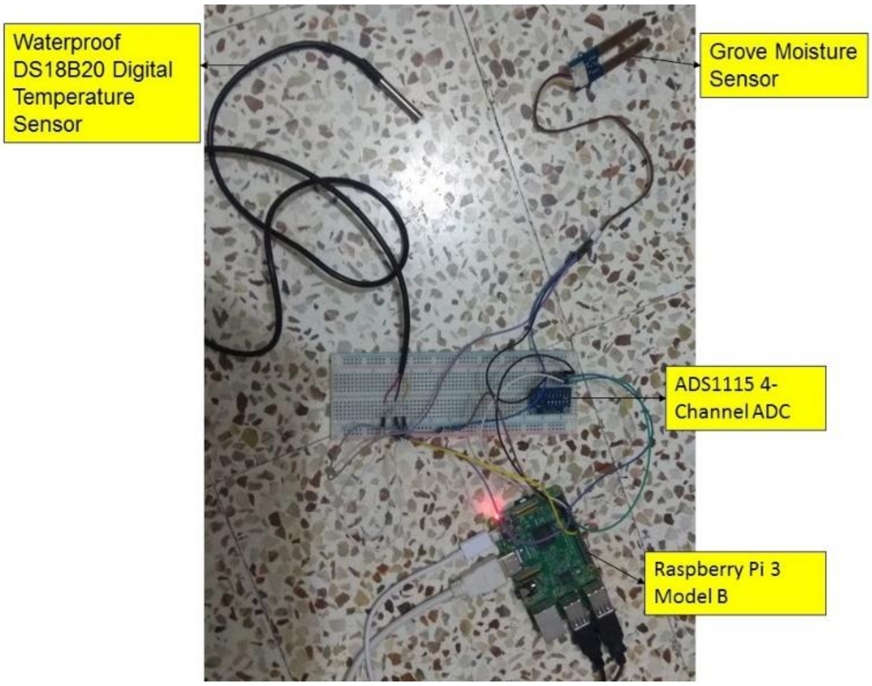

Figure 3. Final circuit design of the system

The advantage of using Raspberry Pi is that it can be configured with static IP address. In our system, Raspberry Pi 3 is configured with a static IP address by editing the file with the command in the terminal “sudonano /etc/dhcpcd.conf “. With a static IP address, remote access of the Pi is much easier than having a dynamic IP address. It is configured with the IP address 192.168.1.21.

MySQL database is used to store the collected data by the sensors. It is a relational database management system. To make the development cost low, Apache2 Web Server is used as a server of the database. It is a local host web server. But the system can be easily transferred to a global hosting web server when necessary.Two protocols are used in the development of the system.SSH (Secure Shell) Protocol is used to access the Raspberry Pi remotely.This is also enabled using the “sudoraspi-config” command in the terminal.SMTP (Simple Mail Transfer Protocol) is used to send gmail from Pi to user when a threshold level is reached. The SMTP protocol is enabled in the program explicitly using the SMTP provider with port 587.

The client-side interface is implemented with HTML, CSS, PHP, crontab. HTML and CSS is used in combination to mark up and style the web page. PHP is used to create the back-end, which is server side. It established connection between the database and the client side website.**cron** is the system processwhich will automatically perform tasks according to a schedule. The schedule is called the **crontab**. It is a service of Linux operating system. In our system, this service is used to execute our programs after 5-minute of intervalto collect temperature and soil moisture data.

5. EXPERIMENTED RESULTS

The data collected by the temperature sensor is taken by an experiment at home in a day. The results are found by sensing the temperature with thetemperature sensor is shown in Figure 4.

192.168.1.21/temperature_n.php

Date	Temperature
2017-06-02 18:35:03	29.40
2017-06-02 18:40:02	29.40
2017-06-02 18:45:02	29.40
2017-06-02 18:50:02	29.40
2017-06-02 18:55:02	29.40
2017-06-02 19:00:02	29.40
2017-06-02 19:05:02	29.40

Figure 4. Experimented Temperature data fetched by temperature sensor in the same day with 5-minute interval

Moisture sensor data is taken by an experiment using a flower pot with dry,humid andwater in soil. First the soil was dry, after giving a little water, it became humid, and after giving a lot of water, it became watery. The experimented data collected from the sensor is shown in Figure 5.

192.168.1.21/moisture.php

Date	Moisture Level	Moisture Condition
2017-06-02 10:25:41	0.00	Dry soil
2017-06-02 10:33:29	722.00	Water in soil
2017-06-02 10:33:45	0.00	Dry soil
2017-06-02 10:44:11	0.00	Dry soil
2017-06-02 10:45:11	72.00	Dry soil
2017-06-02 10:46:02	823.00	Water in soil
2017-06-02 10:46:22	0.00	Dry soil
2017-06-02 10:48:34	719.00	Water in soil
2017-06-02 10:50:01	726.00	Water in soil
2017-06-02 10:50:10	651.00	Humid soil

Figure 5. Experimented Moisture data fetched by moisture sensor

6. SUMMARY AND CONCLUSION

A web interface is successfully developed to collect data from a system based on Internetof Things(IoT) and Wireless Sensor Network (WSN). This system can be used in a remote area and it can serve as a benefit to the farmers.They do not need to go to their field regularly to check the weather. They can easily monitor the weather if they live far away from the fields. It can help them to concentrate on other works outside of their farming. The hardware and softwareused in this system is cheaper thanother environment monitoring system. The price of Raspberry pi 3 is very low and is about only $35. It is also environmentfriendly as the power consumption of Raspberry Pi is very low. It can be deployed at an outdoor location for a long term basis. As all the software and programming tools which are used also open source, it keeps the cost of the development very low. As a future work, system proposed here can be expanded in different ways.Security in IoT is a great concern today as the IoT devices are increasing rapidly.Alsoenormous data problem will also arise when the system will be deployed in a large area in real life.Taking these accounts, in near future,we would like to extend this system with security so that no authorized access can be made and cloud storage for the system to make the systemmore scalable in future deployment. Taking data from the sensors, some statistical analysis can be madeto forecast the weather for particular area or proper time of cultivation of crops like paddy, corn etc.

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