Greenhouse Farming Using Wireless Sensor Network Based on IoT

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Abstract: ***For those who travel across the world abnormally, automatic farming systems are very suitable and reliable. If they are fixed and coded properly, automated farming systems can save lot of your money, advice and provide you information regarding any anomalies instantly so that appropriate action may be taken. Dead vegetation, greenery and plants need to be changed or substituted, and that can be big-ticket and the accumulation of information from automated farming systems can go beyond that. The proposed automated farming system contains a SoC, transceivers, and analog to digital converters which together collect and analyze the information. The analyzed data can be displayed as information in PC or mobile having Wi-Fi connection if there are any anomalies in the detected sensor values like (temperature, rainfall, moisture, PH), and then appropriate action may be taken. The following arrangement makes limited ecology accessible in automatic irrigation implementation.***

Keywords: Wireless Sensor Network, Automated Farming, IoT, RaspberryPi (Cortex A-53 Processor), Various Sensors, MCP3008 (Serial Peripheral Interface)

1. Introduction

It is very important to automate agriculture in a country like India where agriculture contributes to about 86% of India's economy. If the economy has to increase then the agricultural production has to increase and for increasing the agricultural production there is a need to automate agriculture with lesser or no human intervention, resulting in effective utilization of resources such as water, pesticides, fertilizers and many others. The agricultural production can be increased only through smart farming and smart irrigation techniques where the parameters that are necessary for farming can be monitored and controlled without human intervention. Green house farming is a method or technology of farming wherein a particular crop is grown by creating an environment artificially by adjusting various parameters viz. humidity, temperature, soil moisture and others among many that are required for the growth of the crop concerned. About 95% of crops are grown in open field. Since a very long time, Man has learnt to grow crops under natural environmental conditions. In few of the regions where the climatic conditions are extremely worst, Man has learnt techniques to grow the crop continuously by protecting from extreme cold and many other conditions. Therefore Greenhouse farming is a technology of providing suitable environmental conditions for growing a crop. It is therefore used to protect the crop from extreme climatic conditions like temperature, rainfall, fertilizers, pesticides etc. Hence modern science and relevant technology can be applied in the agriculture sector to enhance the agricultural production. The operation of wireless sensor network (WSN) which gathers the data from various sensors and sends the data to the main server using some wireless technology has been specified in many applications. The information about different environmental factors that collected data assists in monitoring and controlling the system. Some other factors also exist that affect the agricultural productivity to a large degree. These comprise the attack of insects and pests that could be suppressed by spraying proper insecticides and pesticides. It is therefore essential to develop integrated system which will watch out all the elements affecting the yield in each and every stage including cultivation, harvesting and production in order to impart solutions to such problems. This project aims at using various sensors for monitoring and controlling parameters like humidity, soil moisture, rainfall and temperature remotely, which are very significant for growing any crop using IoT. Agricultural domain can be modified from being manual and static to smart and dynamic by automation of agricultural activities leading to higher yield with lesser human intervention. IoT is an advanced and highly developed automation and well organized system which utilizes connectivity (i.e. networking), sensing data and Artificial Intelligence technology to provides intact systems for a product or service. When exerted on any system or any field or business, these systems allow greater lucidity, production and control. Data collection, automation, operations and many more can be enhanced using IoT, by using smart devices and robust empowering technology. Therefore a connected greenhouse is a farming area which incorporates sensors, SoC and various other devices and applications that work synchronously with different technological methods applied in agriculture including smart irrigation and Heating, ventilation, and air conditioning systems. The data is recorded on crop development, pest usage and lighting by various sensors and is sent to an on-field or cloud based server, a web admin console that helps the farmers to customize the system's settings and combine it with other mobile technologies, where a mobile application triggers alerts and outlines the details on greenhouse performance.

2. Architecture

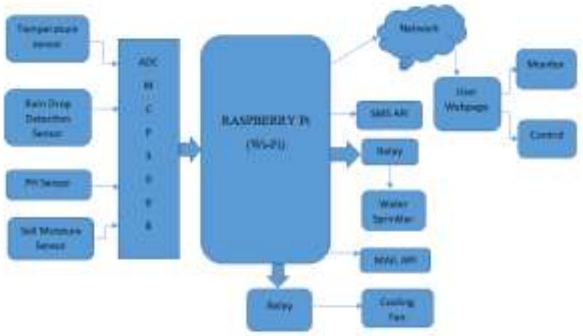
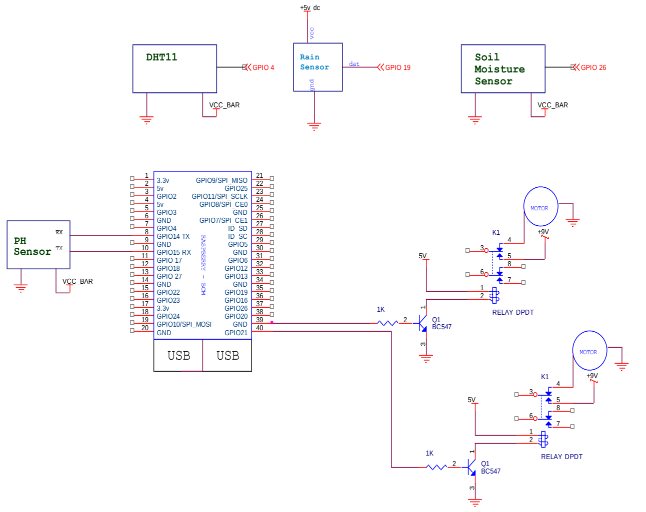


Figure 1: Greenhouse farming arrangement

3. Design and Implementation

The design which is being implemented is in python and the program will run in an infinite loop so that it will keep on updating the values of the sensor. Now first according to the atmospheric conditions of the greenhouse farm concerned, first we have to test the threshold values for every sensor which we are using. The values will keep updating, if any abnormality in the sensor value is observed like in temperature sensor if the value exceeds 400 or 32 degree centigrade SMS and MAIL will be sent automatically, if Rain level is greater than the threshold value say more than 2cm at the same time MAIL and SMS will be sent and Motor will switch OFF , in the case of soil moisture if the moisture is less it will automatically ON the motor to sprinkle water and also send the SMS and MAIL, Web page is designed in such a way that it will be used to update the values at the same time we can control the Motor also. And for PH sensor if the value lies in between 6 and 6.8 then no abnormality is observed but if it is more than 6.8, it means that the soil is alkaline in nature and hence fertilizer has to be sprinkled and hence we will receive an SMS and a mail alert and also the value will be displayed on the webpage. Similarly, if the value is less than 6 then the soil is more acidic and hence to neutralize it water has to be sprinkled and hence DC motor will switch on and we will receive an SMS and mail alert on the web page. All these sensors are analogue sensors and as our Raspberry Pi3 is a single board computer which is programmed in python programming language doesn't have the inbuilt ADC, an external ADC called MCP3008 is used to convert analogue values to digital values. Now our Raspberry Pi3 will update all the sensor values in the server accordingly and automatically on/off the cooling fan and Motor according to the change in the WSN. And a webpage is programmed using HTML and PHP which is saved in the server i.e. Apache server and also SMS API is built to send SMS with the MAIL API to send the mails.

4. Schematic Diagram



5. Hardware Arrangement

Cortex-A53 Processor:

The Cortex-A53 processor on Raspberry Pi is a moderate; low-power consumption digital signal processor which implements the ARMv8-Architecture.The proposed plan uses a Raspberry Pi 3 model B SoC. The Raspberry Pi is a smart card sized, low price SoC (System on Chip) which can be plugged into a desktop computer or television, and a standard keyboard and mouse can be used with the Pi 3 Model B just like any other desktop computer. In other words you can replace the conventional CPU used with your desktop computer by a Raspberry Pi SoC. It is a chip like device that allows anyone to exploit calculations, and to acquire knowledge and understand the ways of programming in languages like scratch and Python.

The Cortex-A53 processor has up to 4 cores, each with an L1 memory system and a single shared L2 cache [22]. Using a wide range of ARM technologies, the Cortex-A53 processor can be integrated into a SoC [23].This processor provides a very high performance along with having very high power efficiency and is used in many mainstream and real time mobile platforms.

Pipelining methods are active because of which all locations of the processing and anamnesis systems can accomplish work in parallel. The ARMV8-A architecture brings a number of new features. These include:

- 64-bit data processing
- The enlarged virtual addressing
- 64-bit general purpose registers
- 8-stage dual issue pipeline
- FPU and Memory performance

There are two execution states in Cortex-A53 processor [23]. They are AArch32 and AArch64. The AArch64 state allows the Cortex-A53 to execute 64-bit applications, while the AArch32 permits the processor to implement the existing ARMv7-Aapplications [23]. All these powerful features of the cortex-A53 processor allow it to be implemented in signal processing, graphics, data processing and many other applications.

SPI MCP3008:

The Serial Peripheral Interface (MCP3008) is a 10-bit, 8-channel Analogue-to-digital converter (ADC). It is a low cost, easy to connect ADC which does not have need of any other extra modules. The Raspberry Pi's GPIO header which supports the SPI bus protocol is used by this ADC making it very easy to interface. The circuit below shows how the MCP3008 can be used to read the values of different sensors. The initial step is to activate the SPI interface present on the Raspberry Pi that is in general disabled by default. It is normally suggested to make use of the manual provided for MCP3008 in order to configure SPI and set up the SPI Python wrapper. The table below illustrates how the connections on MCP3008 can be made using the various pins present on it. The connection with MCP3008 needs four GPIO pins on the Raspberry Pi GPIO Header.

Name	Function
V_{DD}	+2.7V to 5.5V Power Supply
DGND	Digital Ground
AGND	Analog Ground
CH0-CH7	Analog Inputs
CLK	Serial Clock
D_{IN}	Serial Data In
D_{OUT}	Serial Data Out
$\overline{CS}$/SHDN	Chip Select/Shutdown Input
V_{REF}	Reference Voltage Input

Figure 2: Pin Function of MCP3008

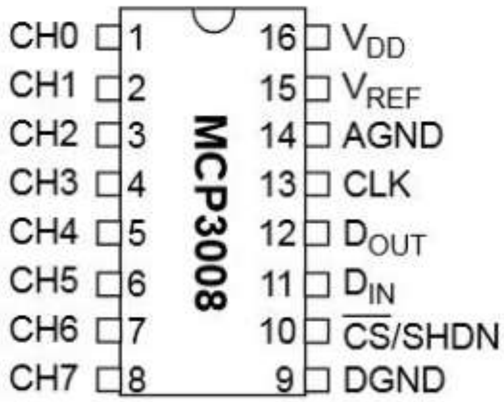


Figure 3: Pin Diagram of MCP3008

Temperature sensor

DHT11 is a sensor that is embedded with both temperature & humidity sensor that comes with a standardized output with digital values. This sensor package makes use of the specially designed digital-signal-acquisition procedure and temperature & humidity detecting methodology which in turn results in more dependability and outstanding long-lasting consistency [10]. This package comprises of a resistive-type clamminess computing module and an NTC temperature computing module which links to a high throughput SoC or any microcontroller, providing exceptional quality, very quick reaction, non-intervention capacity and also reducing the overall price. This package is additionally factory standardized and thereby easy to connect with other microcontrollers. The temperature sensor is capable of sensing temperature between 0°C to 50°C and moisture sensor senses clamminess from 20% to 90% with an accuracy of ±1°C and ±1% respectively. Therefore this sensor is the best option if one wants to determine the temperature or humidity in this limit.

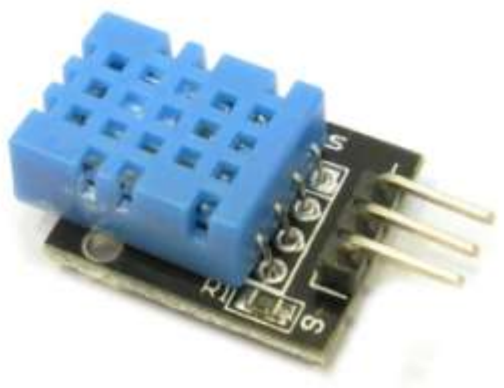


Figure 4: DHT11Sensor

```
if(temp > 30):
print("*** High Temperature ***")
f=open("data.txt",'w')
f.write("\n*** High Temperature ***\n")
f.write(data)
f.close
time.sleep(2)
subprocess.Popen("sudo python
sms.py",shell=True).communicate
```

Rain Drop sensor:

Rain drops can be detected using a rain drop sensor [11].The intensity of rainfall can be measured using rain drop sensor and also is used as a switch when a rain drop falls on the rain detecting board. This sensor contains a potentiometer where sensitivity can be modified, an LED for indicating power, a partitioned rain board and control board for easier use. Drops are measured from the analog output and provided in terms of the amount of the rainfall. If there are no rain drops on the induction board and also when the digital output is high, the LED connected to the 5V power supply will light up. The digital output is low even if there is minimal rain drops falling on the board which in turn will turn on the switch indicator. The outputs become high again when the water drops are removed from the induction board and brought back to the initial state.

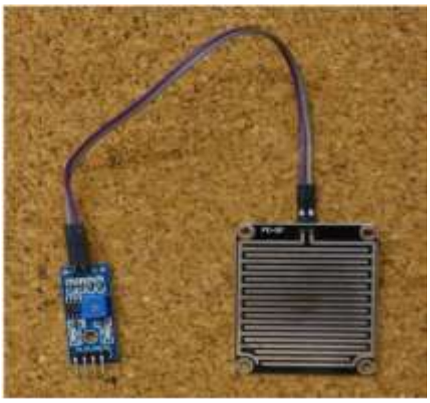


Figure 5: FC-37 Rain Drop sensor

```
if(humi> 60):
print("*** High Humidity ***")
    f=open("data.txt",'w')
f.write("\n*** High Humidity ***\n")
f.write(data)
f.close
```

```
time.sleep(2)
subprocess.Popen("sudo python sms.py",shell=True).communicate
```

Soil Moisture Sensor (SKU-STH1052)

The amount of water present in the soil is measured by the Soil moisture sensor. Farmers can manage their irrigation systems in a more efficient manner when they have the data pertaining to soil moisture. Farmers can not only make judicious use of water for crop cultivation, but they can also increase the efficiency of crop production and the quality of the crop by enhanced understanding or knowledge regarding soil moisture during crucial stages of crop growth**.** LM393 comparator is used by the model in order to relate the existing soil moisture value with the previously defined threshold. There are two binary state outputs with modifiable sensitivity which is a key feature of this soil moisture sensor. The operating voltage range for the input lies between 3.3V and 5V.

Figure 6: Soil Moisture Sensor

```
if(ldr< 50):
print("*** Low Light ***")
  f=open("data.txt",'w')
f.write("\n*** Low Light ***\n")
f.write(data)
f.close
time.sleep(2)
subprocess.Popen("sudo python sms.py",shell=True).communicate
```

PH Sensor

The variations of PHare very significant for the soil, water used for irrigating the crops and water tank solutions. The amount of PH in the water tanks help in knowing the concentration of pesticides present. The amount of PH in the test solutions can be measured using the PH sensors, by determining the activity of the hydrogen ions in the solutions. The activity of these hydrogen ions is collated with the activity of hydrogen ions in clean water which is a neutral solution by means of a pH scale of zero to fourteen in order to identify the acidity or basicity of the test solution. This module works at a baud rate of 9600.

Figure 7: PH Sensor

```
if((6 >ph) or (16 >ph> 9)):
print("*** PH value ***")
     f=open("data.txt",'w')
f.write("\n*** PH value ***\n")
f.write(data)
f.close
time.sleep (2)
subprocess.Popen ("sudo python sms.py",shell=True).communicate
```

DC motor:

The proposed plan uses a DC motor. DC motors are integrated in abundantvarieties and sizes that also comprisereduced besom, servo, and accessory motor varieties. The DC motor consists of a rotating part called as rotor and an abiding alluring acreage stator. The stator is made of either abiding magnets or electromagnetic windings.In any mechanical device,motors are the accessories which accommodate the absolute acceleration and torque. The ancestors include AC motor types like single and multiphase motors, universal, servo motors, induction, synchronous, accessory motors and DC motors (brush-less, servo motor and accessory motor) as able-bodied and linear, stepper and air motors.

IEEE 802.11 Protocol

The Wi-Fi is based on the 802.11 family of standards and is a LAN technology and is used in the altered needs of minimum budget, reduced power requirements for wireless sensor networks. The modules crave basal ability and accommodate definitive supply of abstracts amid limited devices. It provides a data rate of 54Mbps and has coverage of 100 feet. It operates in the frequency band of ISM 2.4GHz.

Advanced Networking & Security

- Permanent link between two end points
- P2MP topology
- Routing based on the destination address, self-healing and fault-tolerant
- mesh networking

Low Power

- TX Current: 295 mA
- RX Current: 45 mA
- Power-down Current: < 1 mA

6. Result

Figure 8: Prototype of Greenhouse Farming

7. Conclusion

IoT-based Greenhouse farming system provides a reliable, smart and efficient system for continuously tracking and regulating various environmental parameters that affect the development of a crop. Essential measures can be taken remotely by the farmer, based on the values detected and notified by the sensors. Wireless monitoring of the greenhouse will not just minimize the manual intervention, but also notifies the user about any anomalies in the sensor values by maintaining accuracy. This system costs lesser and also utilizes less power. The GDP per capita of the farming sector will also be enhanced.

8. Future Work

The financial model of farming can be modified with the help of intelligent robots. Automation of farming can be made possible using equipment embedded with technology that can get information about the entire data of the crop in the farm with the help of digital camera which can be used for harvesting. By attaching sensors to fruits and vegetables which are used for sensing the size and degree of the pigments like chlorophyll, the information about the degree of ripening can be known, which the farmer can use in order to get to know when he can pluck the fruits or vegetables.

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