Sensor Data Acquisition in Smart Farming using Wireless Sensor Network Technology

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***Abstract*—**In today's world due to climate change we are facing a water crisis. Proper management of water resources become even more critical in country like India where agriculture is still the biggest occupation. This paper discusses the data acquisition process of sensors used in smart farming using wireless sensor network technology such as temperature, humidity, soil moisture, light, water level and pH. These sensors along with Arduino and XBee forms a wireless sensor node. A wireless sensor node then transmits the sensor parameters to the Raspberry Pi for taking the decision of turning on/off the irrigation system. Main focus of this paper is on the measurement of weather parameters like temperature, humidity & light and soil parameters like soil moisture and pH.

Keywords*—Wireless Sensor Network; Arduino; Resistance Temperature Detector (RTD), Light-dependent resistor (LDR)*

I. INTRODUCTION

Proper resource management is key to success for any business and agriculture is no exception. Farmers are still dependent on the traditional method of agriculture and practices. Farmers should be benefited with the technological advances to enhance the crop yield with better management of resources like water. In this paper we are going to discuss the sensors which will provide the critical data to our smart irrigation system for better management of water. This paper provides details of sensors useful for smart farming, their specifications, applications and how to acquire the sensor data. These sensors include temperature, humidity, soil moisture, light intensity, water level and pH. These sensors along with Arduino, power supply unit and XBee forms as wireless sensor node in the Wireless Sensor Network (WSN). These sensors provides the data to Arduino, which then transmits the data to Raspberry Pi by using a pair of XBees communicating in the point to point mode. Raspberry pi then takes the decision about turning on/off the drip irrigation system or sprinklers. The sprinkler/irrigation system will also be turned off if the water level of the tank reaches the minimum level as indicated by the water level sensor.

In this paper, section II provides operational details of the sensors like temperature, humidity, light intensity, soil moisture, soil pH and water level. It also provides their functioning, specifications and applications in Smart Farming System using Wireless Sensor Network(WSN).

II. SENSORS FOR SMART FARMING

Researchers in [1] to [8] have proposed numerous solutions to the smart farming domain. Survey of sensors used by them in their systems is displayed in the Table I. For our smart farming using Wireless sensor network system we have selected the sensors which are cost effective and at the same time reliable. This enabled us to lower the development cost of our smart farming system. Sensors are shown in Table I. The next section deals with the measuring the temperature, humidity, light, soil moisture, water level and pH with the help of sensors.

TABLE I. SENSORS

Sr.	Sensor	Sensors in paper [1]-[8]	Selected Sensor
1	Temperature	DS18B20- direct to digital sensor, DHT22-Digital, AM2302, LM-35DZ, MCP9803, DS600.	RTD (Reference Temperature detector) PT100
2	Humidity	DHT11, HIH-4010	HS 230
3	Light	ALS-PT19, Grove, ADPS-9002	Lm393 Optical Photosensitive LDR Light Sensor Module
4	Soil moisture	Groove, FC-28, Hygrometer, VH400, Decagon's EC-5	KitsGuru KG003 Soil Moisture Sensor Module
5	Soil pH	DfRobot SEN0161 analog pH meter	Labman pH meter
6	Water level	VegetronixVG400-LV	Float type potentiometer

A. Measurement of Temperature

For measurement of temperature, we have selected the PT 100 sensor. It's because the PT 100 sensor is the most popular as well as accurate for measurement of temperature. It is known as PT 100 because it has a resistance of 100 Ω at 0 °C and PT stands for platinum. Platinum is used as it's more stable than other materials. PT 100 sensor falls under Resistance Temperature Detector (RTD) sensors. In these types of sensors the resistance is directly proportional to the temperature. So when there is a change in temperature, the resistance of RTD sensor changes. We can hence detect the temperature by measuring the resistance of the sensor [9]. Resistance to temperature conversion for PT 100 sensor is provided in the tabular format in [10]. Features of PT 100 sensor[11] are listed below.

- Temperature range: -200°C to 650°C
- Accuracy: ±0.1°C
- 100Ω at 0°C Nominal resistance

B. Measurement of Humidity

We are using HS 230 sensor for measurement of relative humidity. Relative Humidity is the amount of moisture in the air divided by the maximum amount of moisture that could exist in the air at a specific temperature[12]. The sensor output is in mV. Voltage to relative humidity(RH) conversion for HS 230 sensor and it's specifications are well explained in [13] and same is given in Table II & Table III.

TABLE II. HS 230 CHARACTERISTICS

mV	580	760	1030	1360	1700	2040	2350	2620	2870
RH %	10	20	30	40	50	60	70	80	90

TABLE III. HS 230 SPECIFICATIONS

Rated Voltage	DC 5.0V
Rated Power	≤ 3.0mA
Operating Temperature	0-60^o C
Operating Humidity	10-90% RH
Storage Humidity	Within 95% RH
Storage Temperature	-30 to 85 °C
Accuracy	±5% RH (at 25 °C, 60% RH)

C. Measurement of Light Intensity

For measuring the light intensity we are using the LM393 Optical Photosensitive LDR Light Sensor. A light-dependent resistor (LDR) is a light-controlled variable resistor. The resistance of a LDR decreases with increasing incident light intensity[14]. The sensor module has a potentiometer knob for adjusting the light brightness threshold value. On-board LED turns on when ambient light is greater than the threshold value. Features of light sensor module are listed below.

- Digital Output
- 3 pins- Vcc, Ground, DO
- Comes with LM393 wide range voltage comparator
- Operating Voltage: 3.3-5 V

If the ambient light intensity is greater than the threshold value then DO pin yields LOW(0) value and when the ambient light intensity is less than the threshold value, DO outputs a HIGH(1) value [15].

D. Measurement of Soil Moisture

For measurement of soil moisture we have selected the KitsGuru KG003 Soil Moisture Sensor. Features of soil moisture sensor module are listed below[16].

- Input voltage: 3.3 – 5V
- Output voltage: 0 – 4.2V
- Input current: 35mA
- Dual output mode: Digital as well as analog outputs
- On-board LM393 comparator
- On-board power indicator LED (red)
- On-board digital switching indicator LED (green)
- 4 pins- Vcc, ground, AO, DO

The soil moisture sensor has two probes for measuring the content of water mixed in soil. Current passes through the soil via these two probes. When the amount of water is more in soil i.e. soil is moist, then more current passes though the soil. It means that the resistance of soil is less and hence we can conclude that the soil moisture is higher. Vice a versa, when there is less water in the soil i.e. soil is dry then less current passes through the soil, as dry soil is poor conductor of electricity. It means that the resistance of soil is more and hence the soil moisture content will be less. Here the resistance offered by the soil is inversely proportional to the soil moisture value [17]. Table IV shows the range of soil moisture sensor output values corresponding to the placement of sensor probes in dry soil, humid soil and water[18].

TABLE IV. SOIL MOISTURE SENSOR OUTPUT

Sensor Placed in	Sensor Output
Dry soil	0-300
Humid soil	300-700
Water	700-950

E. Measurement of Soil pH

We are using Labman pH meter for measuring the soil pH. Features of Labman pH electrode are listed below[19].

- pH Range : 0 to 14.00 pH.
- Operating Temperature : 0 to 100°C.
- Zero Point : 7 pH
- Reference Electrolyte : Potassium Chloride(KCl)
- pH Resolution: ± 0.0.1pH
- pH Accuracy: ± 0.0.1pH

The pH meter consists of two electrodes, glass electrode and reference electrode. Glass electrode contains a solution of KCl which is a neutral solution with pH 7. A glass electrode has an internal electrode of silver/silver chloride suspended in the KCl solution. The reference electrode consists of a Potassium chloride wire suspended in the KCl solution. When we dip the pH meter in the test sample of soil, the hydrogen ions in the test sample and KCl solution of glass electrode interact with the glass electrode's outer surface and inner surface respectively. The pH meter converts the potential difference between the inner and outer surface of a glass electrode into a pH value[20]. Soil pH in between 6.5-7.0 is considered as best for most of the crops.

F. Measurement of water level

We are using Float type potentiometer sensor for measurement of water level. The principle of operation of float sensor for water level measurement depends on potential divider method. The water level sensor module consists of a potentiometer, voltage divider, wiper and a float. Float is attached to the wiper via it's arm. Float remains at the upper layer of water. When there is increase/decrease in the water level in the tank, the position of float also changes. This change in position of float causes the wiper to change it's own position. It moves over the potential divider giving rise to an output voltage. This output voltage is proportional to the water level of the tank and will be measured by the potentiometer[21]. Potential divider is provided with the 5V biasing supply. The output voltage measured by the potentiometer will be in the range of 0-2.5V. This output voltage is calibrated to show the level of the water on LCD usually in the range of 0-250 meters.

CONCLUSION

This paper provides data acquisition processes of different sensors used in Smart Farming using Wireless sensor Network technology. In this paper, we discussed different types of sensors that are useful for doing farming in smart way, like temperature, humidity, light, soil moisture, water level and pH. The outputs from these sensors will be utilized to automatically turn on/off the irrigation system or sprinklers by the Raspberry Pi in the Smart Farming using WSN system. This would lead to the optimal utilization of water which is becoming scarce day by day. The output from pH sensor will provide the farmer with guidance related to the soil pH value. Based on it we can provide the smart advise to farmer regarding fertilizers. Also the output from water level sensor will be utilized to automatically turn off the sprinklers if the water level reaches to it's minimum.

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