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Environment and soil analyzing system for inspection of plant growth

Introduction

Our aim of this project is to create a system that can analyze the surroundings and soil by detecting the temperature reading and soil moisture of the soil under test. Additionally, we want to detect the presence of gases like hydrogen, methane, and carbon monoxide in the surrounding. We are calling this project an environment analyzer because upon the results obtained from the sensors we can determine whether the given environment can sustain the growth of plants or other living things based on the level of concentration detected from the sensors.

Application Area

Different regions have different concentrations of components of gases in the air, also the fertility of soil differs from each region to the next. In order to grow plants, vegetation, cropping, and farming, it is very crucial to know the conditions of the soil as well as the surrounding environment. Environments in cities and towns will always have a greater proportion of unwanted gases like hydrogen due to the presence of factories and vehicles which emit harmful gases. In order to determine the quality of gases and the fertility of the soil, to determine the growth of plants we have designed this system that can help farmers and researchers who are working on the properties of soil and environmental gases.

We will be using an MQ8 gas sensor, a soil moisture sensor, and a waterproof temperature sensor. Based on the results obtained from the sensor we can deduce further results. For instance, if there is no water moisture detected and if the temperature of the soil is very high then we can deduce that the soil sample under test is not suitable for the growth of plants. If the air contains high ppm of carbon monoxide then the place is hazardous for human beings, also a high concentration of methane would suggest a highly combustible environment.

Technology and Tools

Sensor Installation

The system would be deployed using three separate sensors. The first of which is the mq8 gas sensor, the second of which is the soil moisture sensor while the last type is the DS18B20 sensor.

The mq8 gas sensor would be used to sense gases like hydrogen, methane, and carbon monoxide in the surrounding. When the sensor is within the range of the three aforementioned gases, it’s conductivity would increase. We aim to convert this change in conductivity to the corresponding output signal of gas concentration by using a simple circuit.

A soil moisture sensor would be used to detect the presence of moisture in the soil of the particular environment which is under test. When the two probes of the sensor will be dipped into the soil sample, the sensor will look for any moisture in the soil. If there is any presence of moisture. If there is any presence of water then we can say that the soil has moisture. When there is water, the soil will conduct electricity which means that there will be less resistance. Therefore, the moisture sensor will detect the presence of moisture in the soil under test.

In order to know the temperature of the soil under test, we will use the waterproof version of the DS18B20 sensor. To set it up, we will connect Red stripe to 5V, the black one to the ground, and Yellow Stripe (contains data) to the digital pin 2 on Arduino. In addition to that, we will need to connect a 4.7K pull-up resistor from data to 5V. We will install the DallasTemperature.h library so that we can issue simple commands to get temperature readings from the sensor.

Language

For writing the codes for this project we used Arduino ide and the Arduino language is C++, but unlike exactly C++ it has quite some built-in abstractions. This is because of simplifying the use of the hardware interfaces. Arduino ide already has loads of built-in libraries for different modules, for our project we had to import **OneWire** and **DallasTemperature** libraries for the DS18B20 sensor, for the rest of the sensors no additional libraries were needed to be imported.

Working Mechanism of Sensors

MQ8 Gas Sensor

MQ8 Gas sensor has 6 terminals in which 4 terminals act as input or output and the remaining 2 terminals are used for heating the coil. Of these 4 terminals, 2 of them from each side can be used as either input or output. This sensor can detect gases based on the willingness of the chemiresistor (Tin Dioxide) to conduct current. SnO_2 is an n-type semiconductor that has free electrons. We know the atmosphere contains more oxygen than combustible gases. The oxygen particles attract the free electrons present in SnO_2 which pushes them to the surface of SnO_2. Since there are no available free electrons, the current would be zero. However, when the sensor is placed in the presence of gases like Hydrogen, Carbon Monoxide and Methane, these gases react with the absorbed oxygen particles and break the chemical bond between oxygen and free electrons. This releases the free electrons to their original position and hence, they can now conduct current. This conduction will be proportional to the number of free electrons present in SnO_2. More toxic gas means more free electrons would be available.

Soil Moisture Sensor

The sensor contains a fork-shaped probe with two exposed conductors that goes into the soil or anywhere else where the water content is to be measured. The fork-shaped probe with two exposed conductors acts as a variable resistor whose resistance varies according to the water content in the soil. This resistance is inversely proportional to the soil moisture. The more water in the soil means better conductivity and will result in a lower resistance. The less water in the soil means poor conductivity and will result in higher resistance. The sensor produces an output voltage according to the resistance, which by measuring we can determine the moisture level. The sensor also contains an electronic module that connects the probe to the Arduino. The module produces an output voltage according to the resistance of the probe and this signal is fed to an LM393 High Precision Comparator to digitize it and is made available at a Digital Output (DO) pin. The module has a built-in potentiometer for sensitivity adjustment of the digital output (DO). We can set a threshold by using a potentiometer; so that when the moisture level exceeds the threshold value, the module will output LOW otherwise HIGH. Apart from this, the module has two LEDs. The Power LED will light up when the module is powered. The Status LED will light up when the digital output goes LOW.

The soil moisture sensor only has 4 pins to connect:

1) AO (Analog Output)- This pin gives us an analog signal between the supply value to 0V and will be connected to one of the analog inputs on our Arduino IDE.

2) DO (Digital Output)- This gives the Digital output of the internal comparator circuit. We can connect it to any digital pin on an Arduino or directly to a 5V relay or similar device.

3) VCC- Supplies power for the sensor.

4) GND- Ground connection.

We will determine the status of the soil by using the digital output. To do this, we will connect the DO pin on the module to the digital pin #8 on the Arduino. The module has a built-in potentiometer for calibrating the digital output (DO). By turning the knob of the potentiometer, we will set a threshold. So that when the moisture level exceeds the threshold value, the Status LED will light up and the module will output LOW.

Now to calibrate the sensor, we would insert the probe into the soil when our plant is ready to be watered and adjust the pot clockwise so that the Status LED is ON and then adjust the pot back counterclockwise just until the LED goes OFF. And finally, our sensor is now calibrated and ready for use.

DS18B20

DS18B20 requires only one digital pin of the Arduino for communication. The sensor communicates using the Dallas Semiconductor 1-Wire® protocol. Each DS18B20 sensor has a unique 64-bit serial code, which allows multiple sensors to function on the same 1-Wire bus. So we can read data from multiple sensors that are connected together with just one Arduino pin. The resolution of the sensor can be set programmatically to 9, 10, 11, or 12 bits. This corresponds to temperature increments of 0.5 °C, 0.25 °C, 0.125 °C, and 0.0635 °C, respectively. The default resolution at power-up is 12-bit. The sensor can be powered with a 3V to 5.5V power supply and consumes only 1mA during active temperature conversions. The DS18B20 has three pins to connect:

1) VDD- This pin supplies power for the sensor which can be between 3.3 to 5V.

2) DQ- This is the 1-Wire Data Bus that should be connected to a digital pin on a microcontroller.

3) GND- This is the ground pin.

Connection with ICs

For the soil moisture sensor, there were options for both analog and digital pins, where the analog pin would give a value between 0-255 to suggest the intensity of the moisture present in the soil sample and the digital pin to give a boolean result of either high or low determining the presence of moisture or not. So here we used the digital pin.

In the case of the temperature sensor (DS18B20), we used a digital pin as it only has the terminals for Vcc, Gnd, and a digital pin.

MQ8 sensor is the gas sensor we used and it had four terminals, Vcc, Gnd, analog pin, and digital pin. We used the analog pin to read the analog value from it and then used the digital pin to print out any presence of hydrogen or methane gas in the atmosphere.

Data flow from sensors through ICs to I/O devices

The Arduino Uno power supply can be done with the help of a USB cable or an external power supply. The external power supplies mainly include AC to DC adapter otherwise a battery. The adapter can be connected to the Arduino Uno by plugging it into the power jack of the Arduino board. Similarly, the battery leads can be connected to the Vin pin and the GND pin of the POWER connector. The suggested voltage range will be 7 volts to 12 volts. Additionally, it has a reset pin and the memory of this Atmega328 Arduino microcontroller includes flash memory-32 KB for storing code, SRAM-2 KB EEPROM-1 KB.

The 14 digital pins on the Arduino Uno can be used as input & output with the help of the functions like pinMode(), digitalWrite(), & Digital Read(). Pin1 (TX) & Pin0 (RX) (Serial): This pin is used to transmit & receive TTL serial data, and these are connected to the ATmega8U2 USB to TTL Serial chip equivalent pins. Pin 2 & Pin 3 (External Interrupts): External pins can be connected to activate an interrupt over a low value, change in value. Pins 3, 5, 6, 9, 10, & 11 (PWM): This pin gives 8-bit PWM o/p by the function of analogWrite().

In our integrated setup the output of all three sensors will be displayed simultaneously in an led display, for the demo we have used the serial monitor to display the outputs and have provided the code in the code section. Waterproof soil temperature will use a digital pin to display the temperature of the soil sample in degree celsius. It has a probe at the end of the wire which is waterproof in nature so can even measure the temperature of wet soil. If the temperature of the soil is at a particular threshold then we can say it is good for cropping or vegetation. Our soil moisture sensor will use a different digital pin to print out the result that will either say soil moisture is present or soil moisture is not present. The presence of soil moisture means that the solid is good enough for the growth of plants or vegetation. MQ8 sensor has both a digital pin and an analog pin, we are using an analog pin to measure the ppm of hydrogen and methane gas and then compare the threshold values and print the values obtained using the analog pin.

A value of higher temperature, no moisture, and high ppm of hydrogen or methane gas would indicate that the location under test is not suitable for plant growth. Whereas, having low temperature and moisture in the soil with a moderate ppm of hydrogen and methane would mean that the environment and soil is good enough to sustain the growth of plants.

Code (not mandatory)

```
#include <OneWire.h>
#include <DallasTemperature.h>
#define ONE_WIRE_BUS 6

OneWire oneWire(ONE_WIRE_BUS);

DallasTemperature sensors(&oneWire);

float Celsius = 0;

const int AOUTpin=0;//the AOUT pin of the hydrogen sensor goes into analog pin A0 of the //Arduino
const int DOUTpin=8;//the DOUT pin of the hydrogen sensor goes into digital pin D8 of the //Arduino

float LlimitOfH = 0.01;
float HlimitOfH = 0.15;
int value;


int msensor = 4; // moisture sensor is connected with digital pin4 of the Arduino
```

```
boolean flag = false;

void setup() {

sensors.begin();
Serial.begin(96000);//sets the baud rate
pinMode(DOUTpin, INPUT);//sets the pin as an input to the arduino
pinMode(msensor, INPUT);

}

void loop(){

//  MQ8

value = analogRead(AOUTpin); //reads the analog value from the  AOUT pin

Serial.print("Methane value: ");
Serial.print(value);

delay(100);


if(value <= HlimitOfH && value >= LlimitOfH){
Serial.print("Hydrogen value: ");
Serial.print(value);
}else{
Serial.print("no hydrogen present");

  }

// DS18B20
sensors.requestTemperatures();

  Celsius = sensors.getTempCByIndex(0);

  Serial.print(Celsius);
  Serial.print(" C  ");
   delay(100);

// soil moisture


  if  ((digitalRead(msensor) == HIGH  ) && ( flag == false ) ) {
```

```
    Serial.println("Soil moisture not present");
    flag = true;
    delay(1);
}

  if ( (digitalRead(msensor) == LOW  ) && ( flag == true ) ) {
    Serial.println("Soil moisture present");
    flag = false;
    delay(1);
}

  delay(100);
}
```

Estimated cost analysis

Name of components	Price in BDT
Arduino uno R3	350
DS18B20 - waterproof temperature sensor	120
MQ8 - hydrogen gas sensor (can also detect alcohol and methane)	180
Soil moisture sensor	100
Breadboard	50
Jumper wires (both Male to male and male to female)	80
Total	**880/-**

Conclusion

Countries particularly in Asia have problems with air and soil qualities due to toxic gases from automobiles and harmful chemicals from factories. Our environmental analyzing setup consisting of gas, temperature, and soil moisture sensors will enable people to know the qualities of air and soil for a particular region. This can also help farmers to choose lands and the desired environment capable of sustaining crops and plants. And all the sensors can be bought and integrated under one thousand takas only, which is cost-effective and will provide better solutions.

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