SOIL MOISTURE MONITORING AND ANIMAL DETECTION FOR SMART AGRICULTURE

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Introduction -

Agriculture Industry is one of the important industries as 45% of the world population depends on agriculture for its livelihood. Irrigation is the vital part of Agriculture Industry. In India, 90% of the fresh water is used for Agricultural purposes and only 10% of the fresh water is used for domestic purposes. After seeing these statistics, it is important to use water very effectively. Measurements of soil moisture have a very evident and direct use. It enables for the quantification of irrigation requirements before a crop shows signs of distress. Knowing the soil moisture state allows efficient irrigation, with water delivered just when it is needed, and no water wasted when irrigation is not required. Another important factor to be considered is animal intrusions. Though the total damage due to this appears less but large portion of the crop gets affected in a single day. This coursework will try to monitor these 2 issues.

Problem Statement -

Soil moisture monitoring and detection of animal intrusion for smart farming system to effectively increase the crop yields and thereby reducing the use of excess water for agriculture which leads to increase in the fertility of soil.

System Specification-

Hardware Specification-

- Arduino UNO WiFi
- Soil Moisture Sensor
- LED traffic Light Module
- PIR sensor
- LCD 20*4 display
- USB cable
- Connecting wires
- Breadboard

Software Specification-

- Arduino IDE
- LiquidCrystal_I2C library

Use-cases-

Use Case ID	UID1
Use Case Name	Lightening up LEDs based on moisture content of soil
Use Case Description	This use case deals with sensing the moisture content in soil and triggering the respective LED for different conditions such as - Red LED- Dry Soil Yellow LED- Wet Soil Green LED- Moisture content is perfect
Primary Actor	Soil Moisture Sensor LED Traffic Light Module
Precondition	1. Soil moisture sensor should be installed correctly and pinned properly to Arduino UNO WIFI. 2. LED Traffic Light Module should be pinned correctly to Arduino UNO WIFI.
Trigger	There are no specific events which will trigger this use case but depending upon the soil moisture, respective LEDs will be turned on.
Basic Flow	Once the soil moisture sensor is installed properly and pinned to Arduino UNO WIFI, it will start giving the reading continuously with the delay of 1 sec. 1. If the water content in soil is too much then it will light up Yellow LED. 2. If the water content in soil is perfect then t will light up Green LED. 3. If the water content in soil is less then it will light up Red LED.

Use Case ID	UID2
Use Case Name	Lightening up Blue LED for animal intrusion
Use Case Description	This use case deals with sensing intrusion and lighting up the Blue LED if any intrusion is detected.
Primary Actor	PIR sensor Blue LED
Precondition	PIR sensor should be properly connected to Arduino UNO WIFI. Blue LED should be connected to the output of PIR sensor.
Trigger	Movement within 10m of PIR will trigger the Blue LED on.
Basic Flow	Once the PIR sensor is properly connected to Arduino UNO WIFI and Blue LED is connected to the output of PIR sensor 1. If there is any movement within 10m from the sensor, the Blue LED will turn on and if the movement is continuous then eventually LED will be turned off again. 2. If there is no intrusion, then Blue LED will remain off.

Design / architecture-

SSM 1- Use case

a. **Main Stakeholders Involved:** Farmers, crops
b. **What are their different Challenges?**
   i. Farmers – Increase in profits
   ii. Crops – Water will be provided whenever needed and if the right amount

c. What are the System Boundaries?

i. Soil moisture monitoring is done with IoT application. Actions should be taken manually.
ii. General intrusion is detected. (Not specific to animals' intrusion only)
iii. Network Lag
iv. Soil moisture sensor data is available after every 1 sec.

d. What important processes / tasks are taking place?

i. Installation and calibration of soil moisture sensor
ii. Measuring soil moisture content
iii. Turning on specific LEDs based on moisture content
    1. If the water content in soil is too much, then it will light up Yellow LED.
    2. If the water content in soil is perfect, then it will light up Green LED.
    3. If the water content in soil is less, then it will light up Red LED.
iv. Sending the moisture content of soil and status to LCD display for every 2 sec.
v. Detection any intrusion and turning on Blue LED.
vi. Based on the detection or measurement, necessary actions should be taken.

e. How can technology help overcome the problem?

i. Increase in the profit for the farmers.
ii. Real time data is made available hence, efficient use of water.
iii. Over-watering or under-watering is avoided.

SSM 2 –

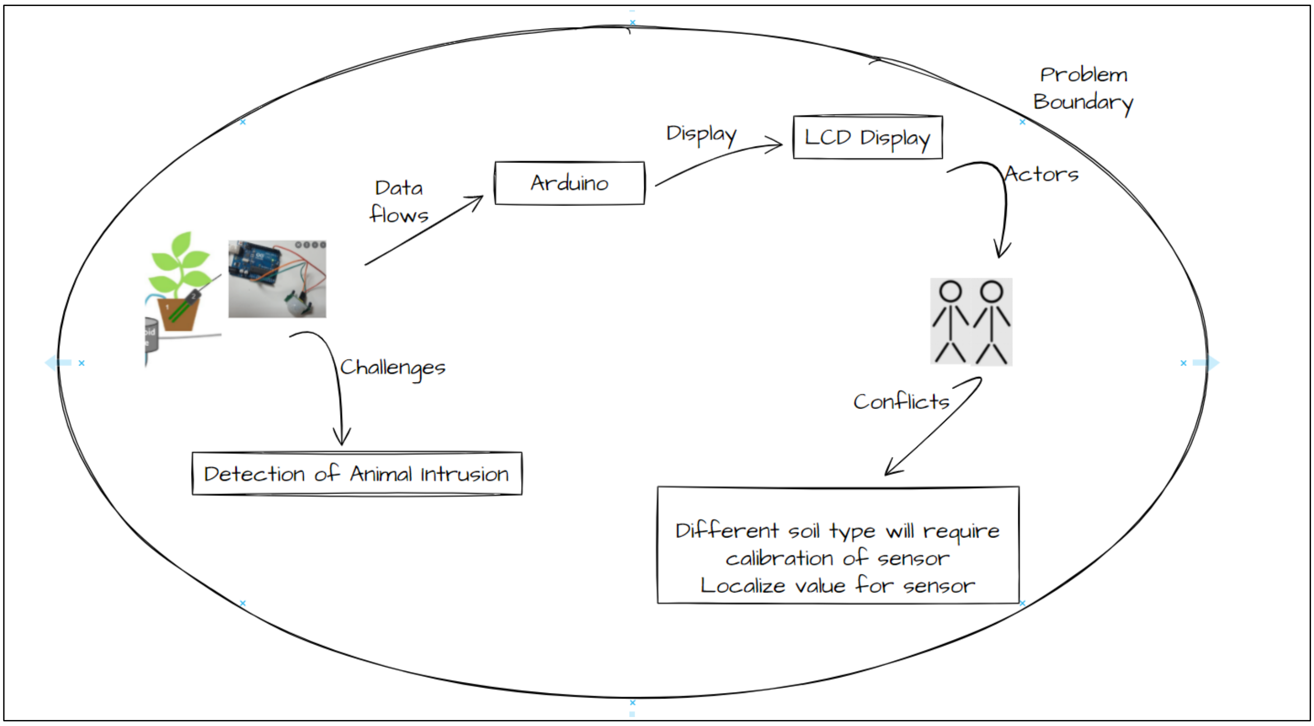

Fig 1. Problem Boundary specification

SSM 3 – Root definition of relevant systems

Human Being's world view –

If the moisture content in soil is low i.e., the soil underneath the plant is dry then Red LED will be turned on. For moisture content in soil is high, Yellow LED will be on and for perfect moisture content Green LED will be on. Soil moisture value will be sent to LCD display along with the state.

If any animal intrusion is happening, then Blue LED will be on.

Plant's world view –

If moisture content is going below specified range or any kind of animal intrusion is happening, then it will be notified to concerned person.

SSM 4 – Activity/ Conceptual Modelling

HTA Diagram

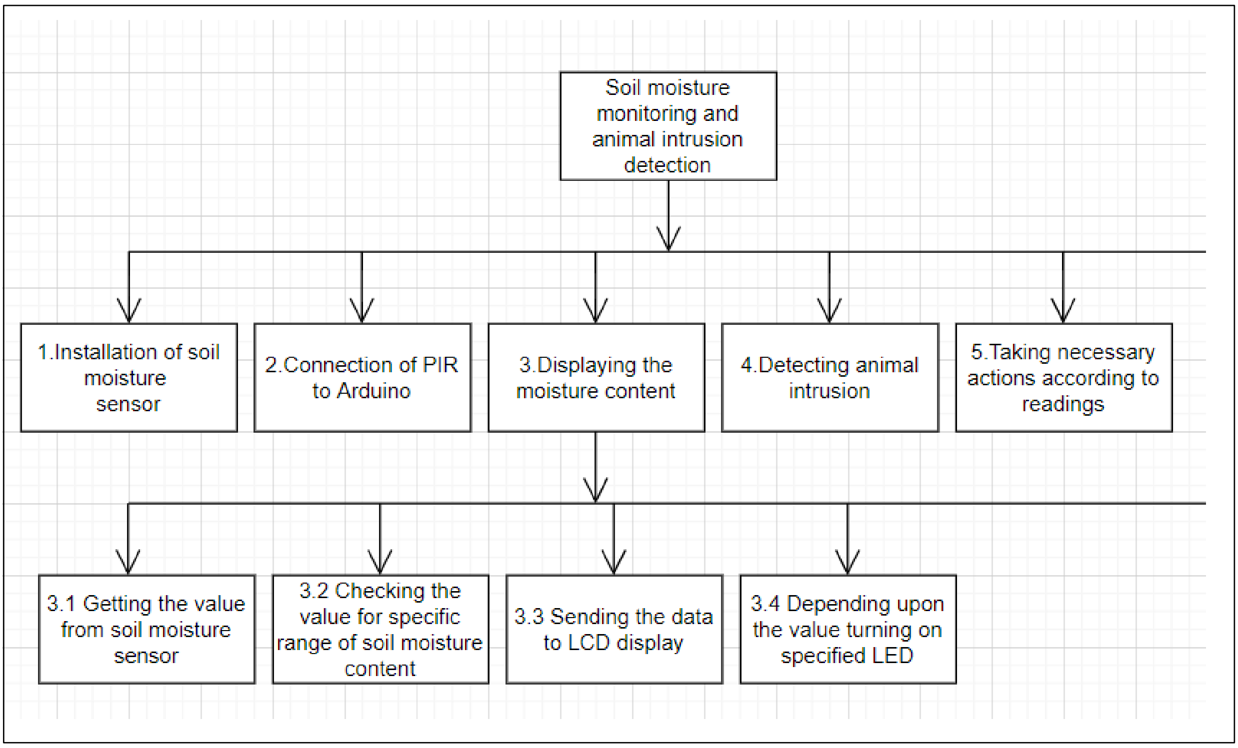

Fig 2. HTA-1

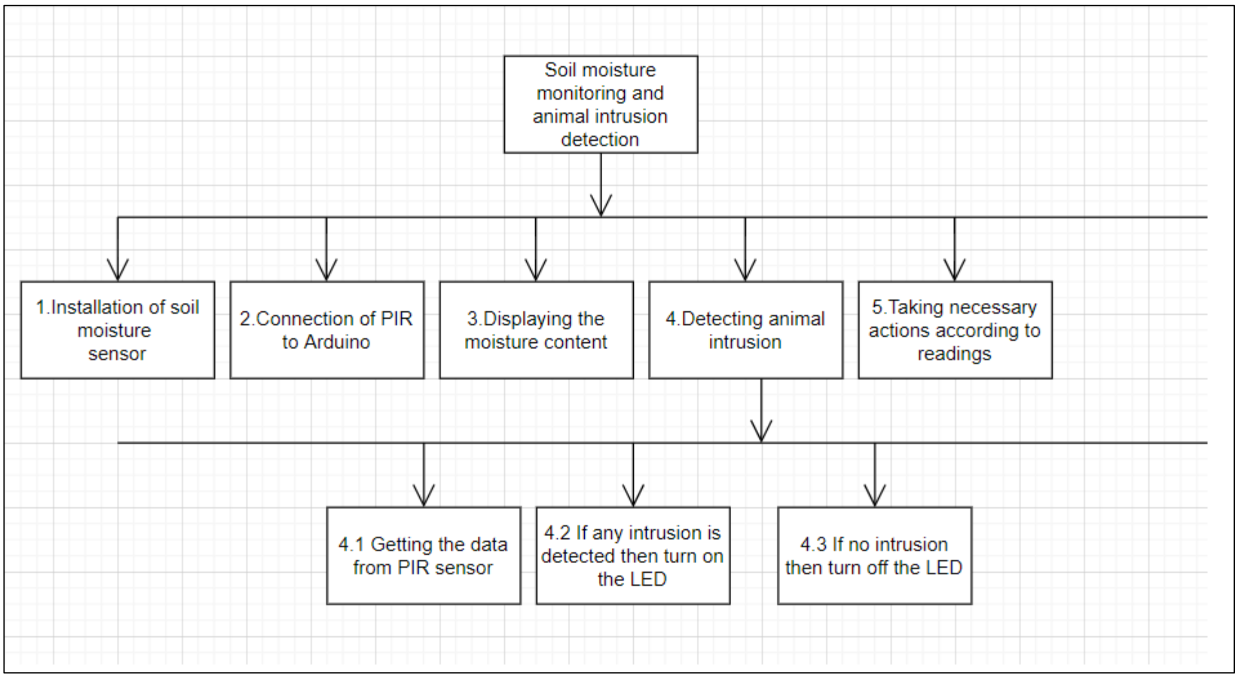

Fig 3. HTA-2

SSM 5 – Comparison of models and real world

In Agriculture Industry, automation is done for supplying water to crops. This automated system will start watering the farm irrespective of considering moisture content of soil. It is so possible that only some part of farm requires water. Hence, using soil moisture sensor, we can get the exact moisture content of soil which will be displayed on LCD display along with respective LED indication. These 2 indications can be used in different locations and necessary actions can be taken. Using these indications plays very vital role as remote area will not have access to Internet.

Animal Intrusion is one of the agricultural problems. If this happens, there are huge losses if we consider it day wise. Detection of animal in the farms will be done by PIR sensor and if any intrusions are happening then LED will be turned on. After successful detection, necessary actions can be taken.

SSM 6 – Changes to the model

The circuit is built on breadboard with 1 soil moisture sensor and 1 PIR sensor along with LCD display and LED traffic light module connected to Arduino UNO WIFI with connecting wires. When we will implement this model in the real world, depending upon the size of the farm, number of soil moisture sensors will be used. All these sensors will generate numerous data and decision must be taken based on combining the data generated by number of soil moisture sensors.

Calibration of the soil moisture sensor should be done every time as structure of soil changes, the capacity of soil to hold water also changes. Conditions for which respective LEDs will turned on will also depend on the type of crop.

PIR sensor detects the intrusions but for detecting animal intrusions, we can use intelligent approaches to detect whether it is an animal intrusion.

SSM 7 – Actions to improve problem situation

- Use of Wifi and mobile application – By sending the data from Arduino UNO WiFi to a mobile application, the data will be accessible from anywhere.
- For intrusion detection – By gathering the data from sensors, we can build a machine learning model to detect whether the intrusion is real or misleading.
- After detection of moisture content in soil, control system can be made for irrigation system. If the soil is dry, start the irrigation system till the soil moisture is perfect.

Design Justification

1. Arduino UNO WiFi – This Arduino has inbuilt wifi module present in it and wifi being the fastest mode of communication, we can use this Arduino to create mobile applications with ease.

2.The values for resistance for dry soil is set to 750 and for wet soil is set to 500. For getting the threshold values of resistance offered by soil moisture sensor, I have measured the resistance in both the conditions.

3. Delay introduced in the system for getting the values of soil moisture content is 1 sec. If less delay is provided, soil moisture sensor is providing garbage values.

4. Physical integrity of the model is poor as it is built on breadboard.

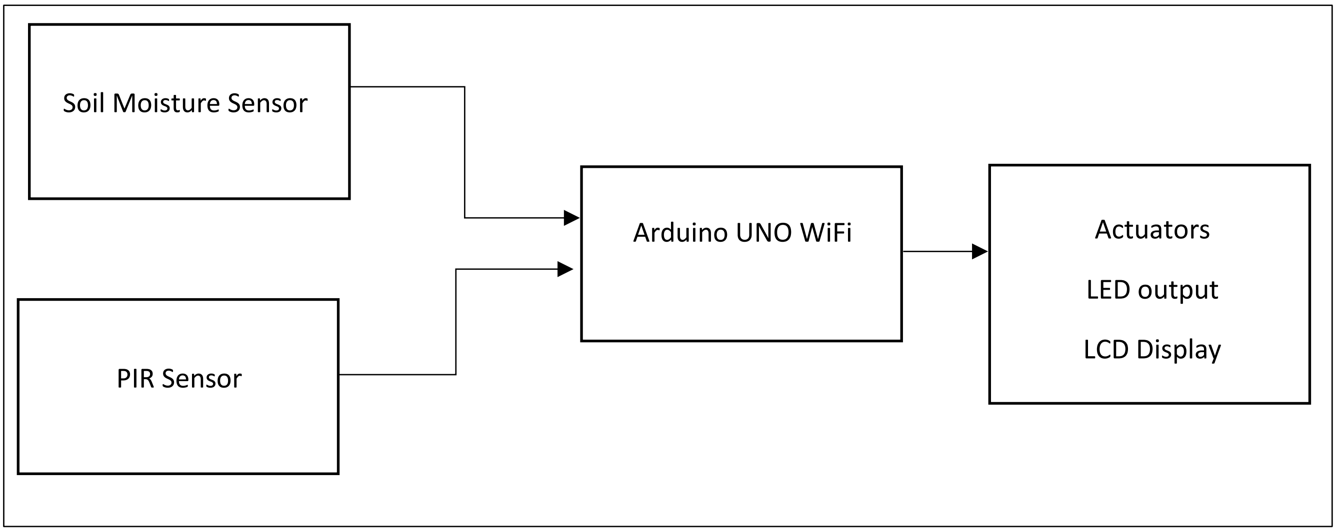

Fig 4. Proposed Model

Fig. 4 above shows the proposed model for soil moisture monitoring and animal intrusion detection for smart farming.

Architecture Diagram

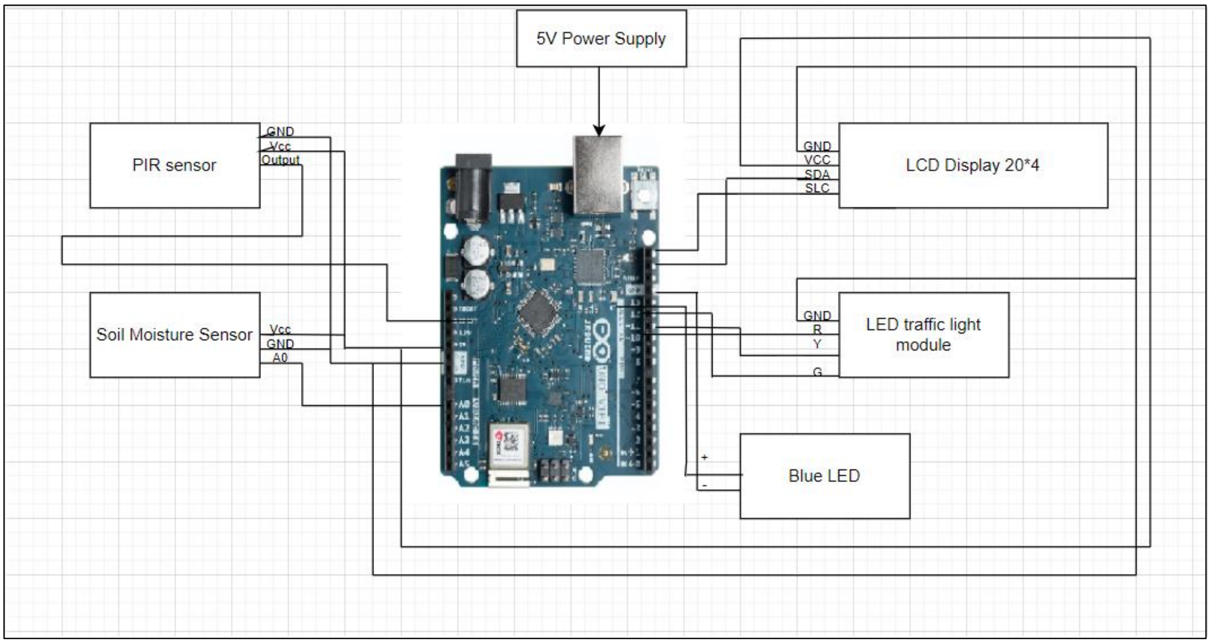

Fig 5. Architecture Diagram

Fig. 5 above shows the architecture diagram for soil moisture monitoring and intrusion detection for smart farming. We have used PIR sensor, Soil Moisture sensor, LCD display, LED traffic light module and Blue LED for the implementation.

Implementation and Evaluation-

In the proposed system framework, Soil Moisture sensor and PIR sensors are used to determine moisture content in the soil & for the intrusion detection respectively.

For the soil moisture sensing, goal is to determine the moisture level units of the soil in integer range and parse the data directly to Arduino and then displaying it on the LCD display.

For intrusion detection, a PIR sensor is used. It detects when an obstacle occurs in its line of contact and sends the interrupt to Arduino.

Soil Moisture sensor

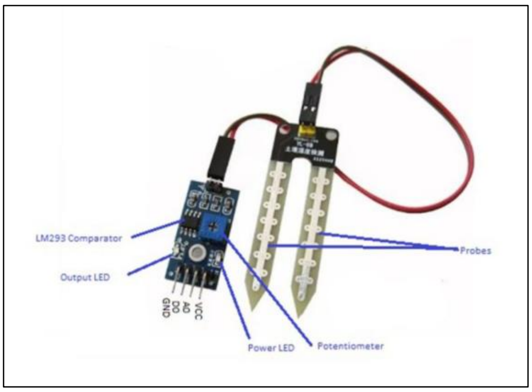

Fig 6. Soil Moisture Sensor

Fig. 6 above shows the soil moisture sensor I have used for this coursework. Working for soil moisture is very simple. The two fork-shaped probs has conductors on them and they act as a variable resistor. The resistance of the conductor varies according to water content in soil.

$$\text{resistance } \alpha \ \frac{1}{\text{moisture content in soil}}$$

Hence, more the value of water lowers the resistance, and less water means poor connectivity, higher the resistance.

This sensor estimates the moisture content in the soil which it has been installed in. It produces digital output in the range of integers. For this project, various experiments using different soil moisture level were conducted and a reference scale has been established. This data can be saved and used later for the analysis purpose.

According to this scale, following is the output units provided by sensor and the corresponding condition of soil.

This data is retrieved by Arduino and is also used in a more visual way. According to the condition of soil i.e., according to the number of units the data is fed to an LCD display and a traffic light display. LCD display shows the number of units of the moisture level. Traffic light display pops red if the soil is dry, Yellow if the soil is wet and Green if the soil condition is perfect. This comes in handy even if the workers associated with the watering or monitoring activities do not know how to use the data or do not have access to the data. It also reduces the time to go back and check the moisture levels manually hence increasing the efficiency in monitoring.

PIR Sensor

Fig 7. PIR Sensor

Fig. 7 above is the PIR (Passive InfraRed) sensor that I used in the coursework for animal intrusion detection. PIR motion sensor is ideal to detect movement. PIR sensor measures the infrared light from the objects in its fields of view. PIR sensor consists of pyroelectric sensor and generates energy when exposed to heat. If person or animal gets in range of the sensor, it will detect a movement as animal or person will emit energy in form of infrared radiation.

In this coursework, I have connected the Blue LED to the output of PIR sensor. If any animal or person intrusion is happening, then Blue LED will get turned on and workers or associated people will get to know about the intrusion happening. Necessary actions can be taken place to lessen the losses due to the intrusion happening.

LCD Display

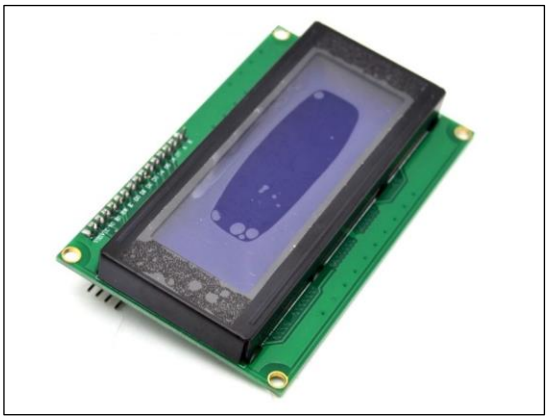

Fig 8. LCD Display

Fig. 8 above shows the 20*4 LCD Display that I used for this coursework. ‘LiquidCrystal_I2C’ library is used to the communication between Arduino UNO WiFi and 20*4 LED Display. This display displays the value of moisture content and status of soil. This LCD Display can be installed in the office of the owner of smart farming system. This display provides readability and instant results. This display continuously fetches the values of moisture content and status of the soil with the delay of 1 sec which is introduced in soil moisture sensor to take readings of the water content in soil.

Code -

```
#include <Wire.h>
#include <LiquidCrystal_I2C.h>

#define soilWet 500   // Define max value we consider soil 'wet'
#define soilDry 750
#define sensorPower 7
#define sensorPin A0
int led = 13;
int led_soilperfect = 12;
int led_soildry = 10;
int led_soilwet = 11;               // the pin that the LED is atteched to
int sensor = 2;              // the pin that the sensor is atteched to
int state = LOW;             // by default, no motion detected
int val = 0;

// Set the LCD address to 0x27 for a 16 chars and 2 line display

LiquidCrystal_I2C lcd(0x27, 20, 4);

int i = 0;


void setup() {

  // initialize the LCD

  lcd.begin();

  // Turn on the blacklight and clear the display.

  lcd.backlight();

  lcd.clear();
  pinMode(sensorPower, OUTPUT);

  // Initially keep the sensor OFF
  digitalWrite(sensorPower, LOW);
  pinMode(led, OUTPUT);      // initalize LED as an output
  pinMode(sensor, INPUT);    // initialize sensor as an input
  pinMode(led_soilperfect, OUTPUT);
  pinMode(led_soildry, OUTPUT);
  pinMode(led_soilwet, OUTPUT);

  digitalWrite(led_soilperfect, LOW);
  digitalWrite(led_soildry, LOW);
  digitalWrite(led_soilwet, LOW);
```

```
  Serial.begin(9600);

}



void loop() {

  // put your main code here, to run repeatedly:

  lcd.setCursor(0,0);
//get the reading from the function below and print it
  int moisture = readSensor();
  Serial.print("Analog Output: ");
  Serial.println(moisture);

  // Determine status of our soil
  if (moisture < soilWet) {
    Serial.println("Status: Soil is too wet");
    lcd.println("Moisture Content " + String(moisture));
    lcd.println("Soil Type: Wet");
    digitalWrite(led_soilwet,HIGH);
    digitalWrite(led_soildry,LOW);
    digitalWrite(led_soilperfect,LOW);

  } else if (moisture >= soilWet && moisture < soilDry) {
    Serial.println("Status: Soil moisture is perfect");
    lcd.println("Moisture Content " + String(moisture));
    lcd.println("Soil Type: Perfect");
    digitalWrite(led_soilwet,LOW);
    digitalWrite(led_soildry,LOW);
    digitalWrite(led_soilperfect,HIGH);
  } else {
    Serial.println("Status: Soil is too dry - time to water!");
    lcd.println("Moisture Content "+String(moisture));
    lcd.println("Soil Type: Dry");
    digitalWrite(led_soilwet,LOW);
    digitalWrite(led_soildry,HIGH);
    digitalWrite(led_soilperfect,LOW);
  }

  delay(1000);  // Take a reading every second for testing
          // Normally you should take reading perhaps once or twice a day
  Serial.println();
  val = digitalRead(sensor);
  Serial.println(val);   // read sensor value
  if (val == HIGH) {            // check if the sensor is HIGH
    digitalWrite(led, HIGH);    // turn LED ON
    delay(500);                 // delay 100 milliseconds
```

```
    if (state == LOW) {
      Serial.println("Motion detected!");
      state = HIGH;       // update variable state to HIGH
    }
  }
  else {
      digitalWrite(led, LOW); // turn LED OFF
      delay(500);             // delay 200 milliseconds

      if (state == HIGH){
        Serial.println("Motion stopped!");
        state = LOW;       // update variable state to LOW
    }
  }
}
int readSensor() {
  digitalWrite(sensorPower, HIGH);  // Turn the sensor ON
  delay(10);              // Allow power to settle
  int val = analogRead(sensorPin);  // Read the analog value form sensor
  digitalWrite(sensorPower, LOW);   // Turn the sensor OFF
  return val;             // Return analog moisture value
}
```

The above snippet shows the code related to the working of the system.

<LiquidCrystal_I2C.h> library is included to display the results on LCD Display. Variables soilWet and soilDry are the values of the resistance that soil moisture sensor shows for the calibration for the type of soil that I used for the coursework. Variables sensorPower is defined to turn on soil moisture sensor and sensorPin is defined for taking the resistance readings. Different LED pins are defined to get outputs on the specified LED.

In void setup () function, LCD display is initialized along with different LEDs output pins.

In void loop () function, readSensor () function is called which is reading the value provided by soil moisture sensor. The value got from this function is then checked against the variables that are declared for dry and wet soil moisture content. If reading is less than 500, code to light up the Yellow LED is written along with code for passing the data to LCD display.

Code for intrusion detection using PIR sensor is also written. Reading is taken from the sensor and if the value is high then state of the LED associated with it is checked. If state is high i.e., if Blue LED is on then variable is set to high and vice versa.

After running this code, we can see moisture content on LCD screen along with respective LEDs changing their state.

Link of the Youtube Video for working - https://youtu.be/zOjCJm_g2qA

Issues associated with the Architecture

1. Scalability – For using the same system in farming industry, some modifications need to be done. In this coursework, I have used only 1 soil moisture sensor. However, for huge farming industries, multiple soil moisture sensors need to be installed and accumulation of the data generated by each of the soil moisture sensor becomes very important. If we want to make the system completely automated then depending upon the status of soil, irrigation system will start and if the soi moisture content is variable in different parts of farms, then also water will be provided to that area, which then will have impacts such as infertile soil and over-watering.

For animal intrusion detection, PIR sensor is used. However, this sensor detects the movement and lights up the LED. For detecting animal intrusion, smart solutions are required to understand whether the intrusion has happened due to animals. Using Artificial intelligence technology this can be achieved. For huge farms, multiple PIR sensors needs to be installed and respective positions should also be known so that quick actions can be taken.

2. Soil moisture sensor needs to be calibrated every time as soil type changes. The capacity of holding moisture content in soil depends upon the type of soil. Along with this, different crops required different moisture content in the soil.

Future Scope -

This system is soil moisture monitoring and animal intrusion detection, we can use the same system for controlling as well. For example, if the soil is dry then soil moisture sensor needs to communicate with the mobile application and end-user will be given control to start the irrigation process. Control button can be provided to turn on and off the motor for irrigation.

Rather than displaying the moisture content on LCD display, it can be showed on the mobile applications and alert events can be generated if permission is required from the end-user.

Use of emerging technologies such as AI can be used for animal intrusion detection.

Conclusion –

Soil moisture monitoring and intrusion detection system for smart farming is monitoring the moisture content in the soil and displaying the moisture content along with the status of the soil on LCD display. Intrusion detection is properly working to detects any kind of intrusions happening. Respective signal is clearly made visible to the end-users so that proper actions can be taken to achieve proper irrigation to crops.

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