Smart Agriculture Decision Support System

Rohan G Koulgi
*Electronics and Instrumentation EngineeringDayananda Sagar College Of Engineering*Bangalore, India
rohankoulgi@gmail.com

Pooja Anand
Electronics and Instrumentation Engineering
Dayananda Sagar College Of Engineering
Bangalore, India
pooja.anand631@gmail.com

Abhinav BL
Electronics and Instrumentation Engineering
Dayananda Sagar College Of Engineering
Bangalore, India
abhinavbhargav8@gmail.com

Medha KM Holla
Electronics and Instrumentation Engineering
Dayananda Sagar College Of Engineering
Bangalore, India
Medhaholla2000@gmail.com

***Abstract*—Indian agriculture is very diverse ranging from impoverished farm villages to developed farm lands using modern agriculture techniques. Despite the perception people may have regarding the agricultural process, the reality is that today's agriculture industry is data-centered, precise and always evolving. Promoting these evolving technologies in the current agricultural scenario will cut down a certain number of problems faced by farmers. The rapid growth of the Internet-of-Things(IoT) technologies restructured the way every industry perceived its work, including "smart agriculture" creating new opportunities and challenges. This system provides an intelligent monitoring platform framework and system structure for facility agriculture ecosystem based on IOT. This will be a catalyst for the transition from traditional farming to modern farming. Overall the main aim of this paper is to provide an easy-to-use monitoring system as well as some functionality to showcase briefly how it could be used as an automatic irrigation system thereby saving time and money for all the farmers present today. By using various sensors in our project we will make them aware about changing terms of moisture in soil, humidity in the air and temperature of the soil as well. Modern agriculture practices have a great promise for the economic development of a nation. So we have brought-in an innovative project for the welfare of farmers and also for the farms. This detailed review will give an efficient way for farmers to monitor their crops and increase their yield naturally.**

***Index Terms*—NodeMCU, Adafruit IO, Smart Agriculture, OpenWeatherMap, moisture and humidity sensor.**

I. Introduction

A Smart Agriculture System is at its core a real time monitoring system with some additional functions to showcase the range of its effectiveness. It monitors parameters like soil moisture, soil temperature, humidity and other miscellaneous parameters. It would be used widely by farmers to get this type of live data for efficient environment monitoring which will in turn increase their overall yield and quality.This System would use a futuristic approach to utilize the concepts of IoT in which an individual gets to control his crops using an IoT platform. This type of technology is designed for ease of use by anyone around the world.

Another big feature of this particular system is the ability to read the weather forecast on the IoT platform fairly accurately using an API from OpenWeatherMap. This can be a very useful feature for areas with unpredictable weather since the forecast will alert any farmers about any impending thunderstorms.

II. Literature Review

[1] This paper implements wireless sensor network based automated irrigation system for optimized water usage for agricultural purpose. The system consists of distributed wireless sensor network of soil-moisture, and temperature sensors placed in the crop field.

[2] This paper also develops an automatic watering and irrigation System that can be used to improve the conventional systems. The project is not only restricted to the agricultural field but can also be implemented at our homes or at commercial establishments having accommodation for lawns and plants.

[3] Node MCU is an open-source and LUA programming language based firmware developed for ESP8266 Wi-Fi chip. Also, many researchers described the various applications for agriculture using IoT. It helps us to monitor Climate Conditions, soil moisture, temperature, humidity, greenhouse automation, crop management, and many more.

[4] This article includes a way to develop an embedded system to design a weather monitoring system which enables the monitoring of weather parameters in an industry

[5] The industry is now moving towards agricultural modernization by using modern smart technologies to find solutions for effective utilization of scarce resources there by meeting the ever increasing consumption needs of global population. With the advent of Internet of Things and Digital transformation of rural areas, these technologies can be leveraged to remotely monitor soil moisture, crop growth and take preventive measures to detect crop damages and threats

[6] The idea of Internet of Things was brought into reality in the concept of Smart farming. This term represents a general concept for the ability of network devices to sense and collect data from all around the world and share it on the internet so that each and every one can make use of it.

[7] This paper develops a model based on the real-time monitoring system for agriculture using IoT. This model works with the help of Wireless Sensor Networks. Due to the uneven distribution of rainfall, it is very difficult for a farmer to monitor and control the equal distribution of water to all crops in the whole farm. By real-time monitoring system, one can easily prevent this kind of problem.

III. PROPOSED SYSTEM

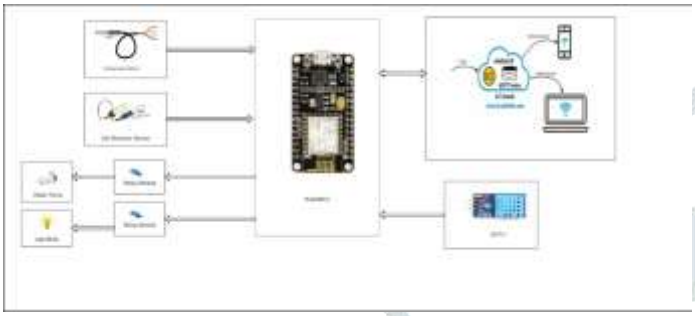

Fig. 1. Block Diagram Of the System.

The main aim of the smart agriculture system is to monitor the Live data coming in through the IoT platform and perform informed decisions essentially becoming a decision support system. Fig. 1 explains the project with help of a block diagram. This project is divided into three major parts:

1) Hardware Configuration
2) IoT platform (Adafruit IO)
3) Weather Forecast (OpenWeatherMap API)

A. Hardware Configuration

a) NodeMCU: NodeMCU is an open-source Lua based firmware and development board specially targeted for IoT based Applications. It includes firmware that runs on the ESP8266 Wi-Fi SoC from Espressif Systems, and hardware which is based on the ESP-12 module. In this project the NodeMCU is used as the base microcontroller to which different sensors are connected.

b) Soil Moisture Sensor: A simple soil moisture sensor for gardeners. Soil moisture sensors measure the volumetric water content in soil. Since the direct gravimetric measurement of free soil moisture requires removing, drying, and weighting of a sample, soil moisture sensors measure the volumetric water content indirectly by using some other property of the soil, such as electrical resistance, dielectric constant, or interaction with neutrons, as a proxy for the moisture content. The relation between the measured property and soil moisture. It is an easy to use digital soil moisture sensor. Just inserting the sensor in the soil can measure moisture or water level content init. It gives a digital output of 5V when moisture level is high and 0V when the moisture level is low in the soil.

c) DHT11 Sensor: DHT11 is a Humidity and Temperature Sensor, which generates calibrated digital output. DHT11 can interface with any microcontroller like Arduino, Raspberry Pi, etc. and get instantaneous results. DHT11 is a low cost humidity and temperature sensor which provides high reliability and long term stability. Since we are using a NodeMCU which has only a single analog input pin, this is the best sensor to measure humidity and temperature as it uses a digital pin.

d) DS18B20 Soil Temperature Probe: This is a 1 Meter Long Waterproof, sealed and pre-wired digital temperature sensor probe based on DS18B20 sensor. It is very handy for when you need to measure something far away, or in wet conditions. Because they are digital, you don't get any signal degradation even over long distance. This kind of probe will be of utmost importance to farmers since it can accurately give the soil temperature and is much more convenient to use than any kind of sensor.

e) LDR Sensor: The LDR Sensor Module is used to detect the presence of light / measuring the intensity of light. The output of the module goes high in the presence of light and it becomes low in the absence of light. The sensitivity of the signal detection can be adjusted using potentiometer. In any kind of farming setup, this sensor will effectively act as a detector to some plants as they would require a certain kind of light to grow better. Thus we can use this sensor in conjunction with any kind of switch or LED strip to provide the plants with adequate light.

B. IoT Platform (Adafruit IO)

Adafruit IO is an open data platform that allows you to aggregate, visualize, and analyze live data on the cloud. Using Adafruit IO, you can upload, display, and monitor your data over the internet, and make your project IoT-enabled. You can control motors, read sensor data, and make unique IoT applications over the internet using Adafruit IO. This platform allows you to create feeds for each of the sensors so as to monitor them periodically as the value keeps changing every few seconds. We have created all the feeds required in this project and have also included a few graphs to visualize the moisture and temperature data for the past values to better plan the next harvest by farmers.

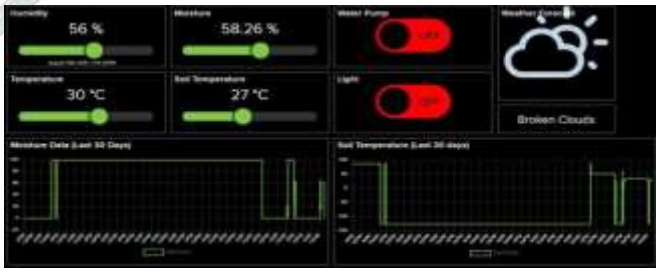

Fig. 2. Dashboard of Adafruit IO.

Fig.2 shows the dashboard of the IoT platform where we see all the parameters included in a very easy to understand

way. There is also a way to control the water pump and Light bulb from the dashboard, thus making it easy for the farmers to control their entire fields by a single button.

When you log into your account, click on 'View AIO Key' on the top right corner to get your account username and AIO key. When you click on 'AIO Key,' a window will pop up with your Adafruit IO AIO Key and username. This is needed later for the code to be used. After all this is done, we create different feeds for the dashboard to look good and easy to use.

C. Weather Forecast (OpenWeatherMap API)

As mentioned earlier, we have also chosen to display weather forecast on the Adafruit IO dashboard and for that, we will use OpenWeatherMap API to request the day's weather forecast for chosen location. OpenWeatherMap provides highly recognizable weather products that make working with the weather data a way easier. This data can be accessed via fast, reliable APIs that follow industry standards and compatible with different kinds of enterprise systems. OpenWeatherMap offers both paid and free plans and here in this project, we have used its free plan to get the weather forecast data.

Now to actually integrate the weather into our Adafruit IO dashboard, we need to get the API key from the website. After this is done, we are use a 5 day / 3 hour forecast data API. This API includes weather forecast data with 3-hour gap and forecast data is available in JSON or XML format. We have chosen to use the JSON data, the next step will be generating the code by which we can read the JSON data and phrase it according to our needs. For that we use the ArduinoJson Assistant.

In the first step, we select the processor type, mode, and input type. Then in the next section, paste the JSON data. Then in last step, we will get the code to read the weather forecast data. We will not use the complete code that is generated by the Assistant.

IV. METHODOLOGY

The system is a combination of hardware and software components. The hardware part consists of embedded system and software is the open data platform called Adafruit IO. The platform is hosted online and consists of a database in which readings from sensors are inserted using the hardware.

From Fig.3, it is seen that all the sensors have their signal pins connected to the NodeMCU which is acting as the base micro- controller. This NodeMCU has a Wi-Fi module called ESP-8266, which connects to the network and then transports all the data fed into the micro-controller to Adafruit IO. The NodeMCU is initialized and synchronized with different sensors to make a mini system to control the Farm from possibly anywhere in the world with the help of any smart device or tool by using a cloud network.

The system enables ease of access to information that is to reach to the user immediately because we live in an era where internet is reaching the destination faster than a clock ticking for a second. For programming the ESP8266

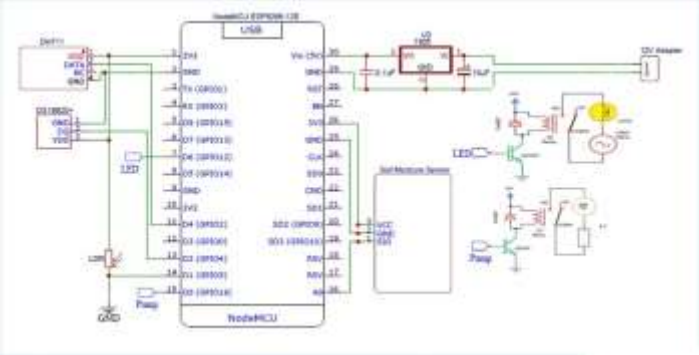

Fig. 3. Circuit Diagram of the System

NodeMCU module, only the DHT11 sensor library is used as external library. The moisture sensor gives analog output which can be read through the ESP8266 NodeMCU analog pin A0. The DS18B20 sensor probe is used to get the soil temperature and a soil moisture sensor is used to read the Soil moisture so that the water pump can be turned on/off automatically. If the soil moisture goes below a certain level,it automatically starts the water pump.

A. Programming for the Smart Agriculture System

Here we are explaining some important parts of the code. The code uses the Dallas-Temperature, One-Wire, Adafruit_MQTT, ArduinoJson, and DHT.h libraries. The Adafruit_MQTT.h and DHT11.h can be downloaded online for free, rest of the library can be directly downloaded from Arduino IDE library manager. Then we enter the Wi-Fi and Adafruit IO credentials that you copied from the Adafruit IO server. These will include the MQTT server, Port No, User Name, and AIO Key. Then set up the Adafruit IO feeds for storing the sensor data and controlling LED and water pump. In our case, we have defined four feeds to store different sensor data namely: Soil Temperature, Temperature, Humidity and Moisture, one feed for displaying Weather data and two feeds to control LED Bulb and Water Pump.

Now inside the setup() function, we initialize the Serial Monitor at a baud rate of 9600 for debugging purposes. We also initialize the DHT sensor, and DS18B20 sensor with the begin() function. Now comes the void loop(). This is where all the tasks are performed. So, in this loop, first we will get the weather forecast data from OpenWeatherMap API, then we will read the sensors data and in last step, we will publish all this data on Adafruit IO dashboard.

a) Reading the Weather Forecast: To read the weather forecast data from OpenWeatherMap API, we will use the code snippets that we generated using ArduinoJson Assistant. Here in void loop, we will only call the API after a particular time interval so that we don't exceed our daily limit.

b) Reading the Sensor Data: Now after getting the weather data, next we will read all the sensor data. Here we are using the DHT11, DS18B20, LDR and Soil Moisture Sensor. LDR and soil moisture sensor data will be used to automate

LED bulb and water pump. So first we will read the LDR status and if the LDR reading is less than 200, then LED will be turned on automatically. Similarly, if the soil moisture percentage is less than 35, then water pump will be turned on.

c) Publishing the Data on Adafruit IO: Now as we have collected all the data, it's time to publish this data on Adafruit IO dashboard, so that we can monitor it from anywhere. Here we have published the different sensor data to their respective feeds.

V. Experimental Results

Fig. 4. Experimental Setup

As seen in Fig.4, in this project we can control the motor in the field based on humidity, temperature and moisture level. The Moisture level of soil is measure or sensed by the sensors. These values are converted into digital form and applied to NodeMCU. If the moisture levels of soil are dropped to a certain level the motor is turned on automatically without human interaction. Similarly, if the value of light in the room goes below a certain value then the LED bulb will go on to signify that light will not be an issue for certain plants

VI. Conclusion

Agriculture is one of the most important sectors in the current world. The modernization of various technologies has allowed us to make further advances in agriculture as well. The result of this project is quite satisfactory as we have created a very easy to understand system which will help all the farmers to monitor their crops and improve the quality of their farms. To make this system profitable, IoT will be used to a greater extent along with machine learning algorithms to implement usage of fertilizers in the soil.

This system can be further improved if we add some sort of image processing concept to identify different diseases on the plants while also looking out for some insects on the plants which could possibly ruin the yield. Designing a platform which connects these farmers to different dealers will make things a lot simpler and profitable for everyone involved.

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