Internet of Farming (IOF) and Internet of Things (IoT)

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Abstract. IoT is revolutionizing the global context on many fronts, including healthcare, e-commerce, transportation, real estate, travel, banking, education, leisure, home automation, and agriculture. Traditional agriculture requires implementing specific tasks, such as planting, fertilizing, harvesting, with a predetermined schedule. With the ever-increasing population, it is not easy to continue on time and quickly as a human being. Introducing IoT in agriculture will be produced in smart outcomes with precision agriculture. This study aims to provide a framework and prototype that include a crop monitoring and response system based on the farmer's needs. The proposed system has four components: sensors, microcontroller, cloud database, and android application. The sensors monitor the environment and changes in the crop continuously. Also, it reacts when the crops need to have severe actions. When the proposed system and the prototype developed with machine learning techniques, the farmer will get the best throughput.

Keywords: IoT, precision agriculture, sensors, microcontroller, cloud database

1 Introduction

IoT is revolutionizing the global context on many fronts, including healthcare [1]–[3], e-commerce [4]–[6], transportation [7], real estate [8], [9], travel, banking [10], education [11]–[13], leisure, home automation [14]–[17], and agriculture [18]–[20].

Agriculture is the route toward making food, feed, fiber, and various other needed things by the development of explicit plants and the raising of trained creatures [21]–[23]. Traditional agriculture requires implementing specific tasks, such as planting, fertilizing, harvesting, with a predetermined schedule. Agriculture and environmental data can be collected and be used for a better decision-making process. These include air quality, climate, crop control, gear, and labor. It is often known as precision agriculture. Alternatively, precision agriculture is considered as applying the right techniques to increase production and enhance the quality of the crops at the right time and right place [24]. Nevertheless, it is not the easiest thing to do. Precision in agriculture is challenging not only for humans but also for the current system available for agriculture because environmental properties are not constant, and it could vary from time to time.

Farmers are managing all aspects of farming without any extra help. Populations in earlier days were low, so a single farmer could produce the yield as expected. However, the effects of overpopulation are impossible to handle, and they require additional resources. Therefore, Farmers must be to increase productivity. With the ever-increasing population, it is not easy to continue on time and quickly as a human being. Traditional approaches are insufficient for this problem. The farmers need technological solutions for precision agriculture.

Once after the advent of the Internet of Things (IoT) [25]–[27], the world's many aspects change their dimension differently and efficiently. The concept is applied in the various domains to solve challenging problems more efficiently. Moreover, it proceeds as expected. The advantages listed with this concept are; high productivity, efficiency, versatility, ease of access, and many more. The principal concept of the IoT is that it is connected to every single object, with sensors that can respond to situations as they arise. The applications of the IoT are comprehensive and cost-effective. Hence, many industries and domains employ this concept though it is new. The sensors typically detect every environment's characteristics and react according to that promptly. As aware, in precision agriculture, a farmer needs to respond promptly based on the situation. In that respect, IoT techniques are the best approach to obtain the maximum yield without even very few defects. Introducing IoT in agriculture will be produced in smart outcomes with precision agriculture. Therefore, this study aims to identify the current agriculture trend and provide a solution with IoT, cloud, and mobile applications.

2 Literature Survey

2.1 Functional (Systematic) Review

[28] Developed a system called "Smart Agriculture Using IoT". This system contains three layers: the perception layer, the network layer, and the application layer. Using these layers, IoT provides decision making and advanced warning based on environmental requirements and changes. Perception layer responsible for monitoring humidity, temperature, pressure, and light intensity via Ubi-Sense mote. It monitors all local data through a sensor embedded in it. Also, they are maintaining a web camera near the crop area, which produces the real-time activities of agriculture. This collected local data from Ubi-Sense mote passes to the Application layer via Network Layer. In the network layer, they use wireless technology to pass the data via air. Once the data passed to the cloud, users can login via smartphone or web-based applications. They can monitor the changes and make a reliable decision based on the situation; hence the agriculture will not suffer from the environment. They also maintained the GSM module; thus, users get real-time alerts via SMS.

[29] et al. developed a system with IoT and image processing for Smart agriculture. The aim of this system is continuously monitoring the health of the crop using image processing technique to the lush crown of the crop. This system contains a microcontroller for connecting all devices. Temperature, humidity, soil moisture, and light intensity sensors are connected as an input of the microcontroller. A camera module is connected with a microcontroller that captures the image.

Additionally, there is an SD card module added along with microcontroller, which is store all sensed output and image which captured from the camera module. Once all data stored in an SD card, the captured image checked via a Histogram diagram using some algorithm with MATLAB software. After the gained the result of the histogram, the sensed output compares together with that. Based on the variations and identification, they will decide to maintain their health.

[30] et al. developed an Internet of a farming system. This study is entirely based on cloud storage with IoT. And sensor nodes. The sensor nodes are positioned next to the plants and are monitored continuously by the nodes. As soon as the changes happen, the farmer will be notified. Here necessary sensors are used at the crop area, and collected data from each plant sends to cloud storage. They need to pick Microsoft Azure, AWS, IBM, and Google Compute Engine for a cloud environment. When the data stored in the cloud, farmers can login into their account using a specific application designed for this purpose and can get the benefits.

[31] Proposed a system for the Internet of farming called "Internet of Things (IoT) for Smart Precision Agriculture and Farming in Rural Areas". This system is entirely based on wireless sensor nodes (WSN) and IoT. IoT sensors are placed nearby the farm and agriculture fields in rural areas. Sensors collect frequent data, which will pass the cloud via a wireless sensor network. To abduct farm data to a wireless sensor network, they used a border Router, and to pass the data from WNS to the cloud, they used a Gateway. Once the data received in the cloud, Farmers can have a decision based on that data.

[32] et al. developed an Internet of Farming (IoF) system with IoT called "Applied Internet of Thing for Smart Hydroponic Farming Ecosystem (HFE)". Arduino microcontroller plays a significant role in this system, and it serves as a platform for connecting other devices. Sensors like pH, EC, Water Temp, Humidity, and Temperature sensors act as an input device of the microcontroller. With the help of sensors, the farm is frequently monitoring. The monitored data will transmit to the server via a Wi-Fi shield and MQTT broker. Once the data reached the server, users can view the necessary information from the server via a smartphone. There is a unique android application design to make this happen.

[33] et al. developed a structure called "Advance Agro Farm Design with Smart Farming, Irrigation and Rainwater Harvesting using Internet of Things". This system is entirely based on IoT with cloud, with Arduino microcontroller's help as the platform for connecting other devices. Soil Moisture sensor, water pump, and Direct Current (DC) motor connected with relay and water level detection sensor are working as an input of the microcontroller. Collected data will be stored in the cloud via the Internet using an Internet gateway. The system (Farmer) can acquire farm-related information using a smartphone or other computer IoT platform.

[34] Studied smart farming using Image processing as a disease detection system for fruits. This system worked thoroughly with web and fruit farm pictures. The disease images data set is used to train the web system for prediction. The user of the system login to the system with authentication, and he/she needs to upload the captured picture of the fruit to a web-based image processing system. It will be compared with the dataset and classify the disease to come up with the solution. Moreover, disease severity is also detected using multiple image processing steps by comparing with the trained dataset images. They applied K-means algorithms and SVN classifications for comparison and other tasks.

[35] et al. had a study using IoT for monitoring agriculture. This system was developed based on a three-tier architecture, namely, Sensor Network tire, Gateway tire, and IoT cloud tire. A microcontroller with an SD card, an LCD i2c module, a soil moisture sensor, and other appropriate sensors in the sensor tire. Data stored from SD card routes to IoT cloud using GPRS, sensor network, and Wi-Fi technology. In the cloud, the system user can view and have a decision based on that.

[36] developed a system for the Internet of Farming is called "IoT Based Smart Sensors Agriculture Stick for Live Temperature and Moisture Monitoring using Arduino, Cloud Computing & Solar Technology". This system also worked based on a microcontroller. The main aim of this study is lively to measure the temperature and moisture in a farming

environment. Each sensor is placed as an input to the Arduino, and output data stored in the cloud using the Wi-Fi module. To get the power to this circuit, they have used the solar technology, and solar power is injected into the Arduino power supply.

Apart from the crop mentioned above-related developments using IoT, [37] et al. had designed a farming system called the Internet of Things (IoT) to manage Smart Animal Farm. This system has several subsystems and components such as a biogas control system, feed control system, incubator control system, fire detecting system, and Internet Protocol camera-based surveillance system. Each system is maintained based on a specific area. Every system Arduino microcontroller plays a significant role. Necessary sensors like a Gas, Ultrasonic, DTH, Fire Water level, and Camera module are placed as input to the microcontroller. The data are coming from those sensors store the server using via Wi-Fi using the Ethernet shield. The user of the farm can monitor the information by specific GUI application software developed for this farm.

[38] Had developed a system for watering system and soil moisture levels called "Vertical farming monitoring system using the internet of things (IoT)". This system is working with a microcontroller called BeagleBone Black. All the sensors (water, LDR, Temperature, and soil moisture) are placed in the analog pin of the microcontroller as an input. The data coming from the input sensor are upload to the Thingspeak IoT cloud via LTE 4G using the Sierra Wireless module. At the other end, there is a web-based application developed for accessing the data in the cloud. In this web-based application analysis, the cloud shows the graph, chart, and table to understand users efficiently.

[39] et al. developed a chicken farm system based on IoT called "IOT Based Smart Poultry Farm". Here PIC microcontroller act as a platform and temperature, humidity, water and gas sensor connected as an input. Cooling fan, exhaust fan, ventilation window, and DC motor act as an output device with a relay's help. Further, PIC connected with a Wi-Fi module. Whenever temperature increases considerably, the temperature sensor informs the microcontroller, and it will inform the fan via a relay. The fan on automatically until the temperature becomes a necessary level. Typically ammonia gas affects the growth of chicken; hence, the gas sensor identifies the ammonia level. If it raises more than the threshold value, it informs the PIC, and the ventilation window will open. Likewise, every sensors and output devices follow the same protocol. All changes from the sensors are frequently uploaded to the customized web page via a Wi-Fi module. The user of the system can monitor all information either by using a smartphone or personal computer.

2.2 Non-Functional (Systematic) Review

Nowadays, farmers and farm owners who are making different products having a variety of trouble due to environmental changes, rainfall, and some other factor. Farmer suicides are quite familiar with this. To overcome this problem, most of the studies proposed smart farming and automated system with the aid of IoT, which reduces the problem significantly and considerably [40], [41].

Concurrently most of the time in smart agriculture and internet farming, most users and researchers are focused on collecting environment-related data such as temperature, humidity, soil moisture, and pH [42].

As stated by [43] et al. that Drones and Unmanned Aerial Vehicles are playing significant roles on the Internet of farming or Smart Farming. With the help of this technology can be obtained or monitored the state of the crop, virtual or geo fencing activities, decision making, and easy management of farming activities. Also, mentioned that, by using the drone in agriculture, it increased by 80% worldwide. Another significant technology in agriculture and farming is Robotics. The problem is this technology is higher cost since a specific area uses it. It is used by the dairy industry up to 30% these days [45].

Another report from the United Nations that every year there is a 1.10% increase in the world population. It will be reached 8.6 billion in 2030 and 9.8 billion by 2050; hence food production needs to be increased by 70% [46]. To overcoming and bearing this problem, Climate-Smart Agriculture (CSA) reported and suggested the Internet of Farming with IoT. Also, they said that this technology only would tackle the problems in the future.

[47] et al. reported from a study that cloud-based farm management systems increase the huge agriculture amount, and the estimated profit at 2022 by IoT cloud technology is 2.71 USD.

[48] Stated that the role of IoT in agriculture is crop monitoring, Soil Management, Water Management, Control of insecticides and pesticides. Also, they mentioned that IoT monitored the product's health and given real-time data for maintaining the good health of that product.

Whenever we transition to the smart concept, there are still two problems we have faced since the beginning of the modern age, protection, and privacy. Typically whenever we move online, there are vast possibilities of missing or stealing data by other parties. Ray and Wolfert et al. stated that the cloud environment of the IoT always providing security with privacy. Also, it provides data management, provision of IoT services, cybersecurity, and analysis of Big Data as well. A cloud-based IoT environment addresses privacy and security; hence it is an impressive and adaptable technology by the farmers [20], [49].

As indicated by [50] et al. that, using IoT and data analytics will help agriculture and farming to get high efficiency with high yield in the current era.

Wireless sensor networks (WSN) currently play significant roles in farming and smart agriculture. These WSN deployed for observing the environment, food protection, abducting precious information promptly. Without WSN, it is tough to pass precious data to the cloud [51], [52]. WSN addresses the problematic area of privacy, security, data governance, and business model in Smart Agriculture and Smart farming [53].

IoT enables farmers to provide profit, making quality products increase productivity with less cost, comprehensive knowledge about the field, and decision support based on the situation. It also addresses the problems and constraints farmers face in agriculture and farms [54], [55].

There are a variety of applications available in Smart agriculture with IoT and Internet Farming with IoT. The most critical applications so far, monitoring irrigation and water [56]–[62], Monitoring weather conditions [63], crop and livestock monitoring [64],[65], and monitoring the machinery [66].

The crop farming operation influence by several factors. It including temperature, humidity, climate, Rainfall, Radiation, Human errors, and soil [67]. This factor typically affects the farmers' in different ways. Proper precautions are an essential aspect for each farmer to minimize the risk and maximize the profit level. The only solution so far by all the researchers and the studies are IoT and IoF, which address all problems by continuously monitoring all properties [68]

3 Methodology

The primary idea of this study is to propose a solution that provides high-tech and cost-effective solutions for precision agriculture. The framework and prototype include a crop monitoring and response system based on the needs.

Figure 1 below shows the conceptual framework of the proposed system. The system has four components; namely, sensors, microcontroller, cloud database, and android application. The microcontroller is connected to a soil moisture sensor, a temperature sensor, a water level sensor, a water pump sensor, a Wi-Fi module, and a GSM module to track crops. The sensors monitor the environment. The crop changes continuously—the sensing data from the crop continuously updated to the cloud firebase through the Wi-Fi module. Whenever any unwanted issues are found, a message will be passed to the farmer via a GSM module and application. Based on the alert type, farmer can make the arrangement as quickly as possible

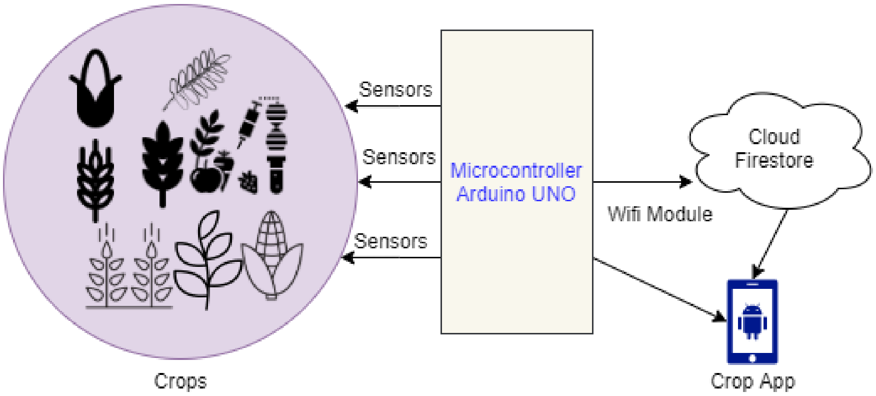

Figure 1: Conceptual framework of the study

4 Results and Discussion

4.1 Sensor layer

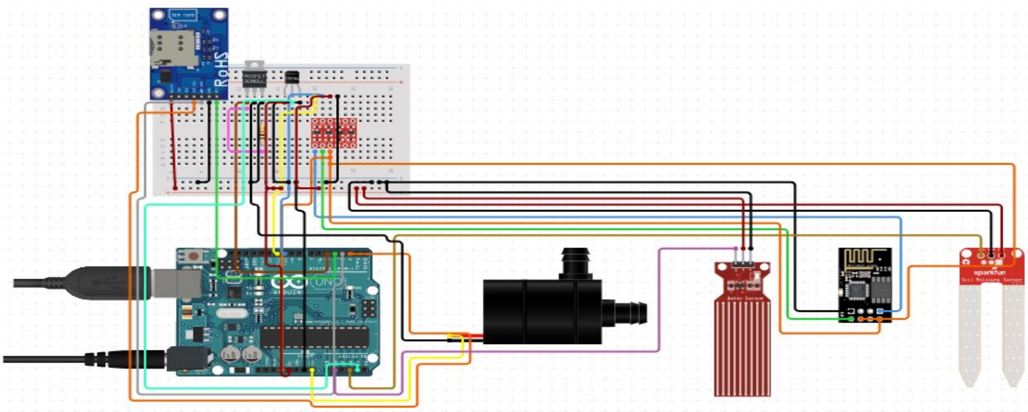

Figure 2: Simulation of microcontroller with sensor

Figure 2 shows the microcontroller with all the necessary sensors needed. A hardware setup is made with a simulation environment

```
// Include Libraries
#include "Arduino.h"
#include "ESP8266.h"
#include "SoilMoisture.h"
#include "Pump.h"


// Pin Definitions
#define WIFI_PIN_TX 11
#define WIFI_PIN_RX 10
#define SIM800L_SOFTWARESERIAL_PIN_TX 2
#define SIM800L_SOFTWARESERIAL_PIN_RX 3
#define SOILMOISTURE_5V_PIN_SIG A3
#define WATERPUMP_PIN_COIL1 5
#define TMP36_PIN_VOUT  A4
#define WATERLEVELSENSOR_5V_PIN_SIG A1


const char *SSID     = "WIFI123";
const char *PASSWORD = "PASSWORD" ;

char* const host = "www.google.com";
int hostPort = 80;
// object initialization
ESP8266 wifi(WIFI_PIN_RX,WIFI_PIN_TX);
SoilMoisture soilMoisture_5v(SOILMOISTURE_5V_PIN_SI(
Pump waterpump(WATERPUMP_PIN_COIL1);
```

```
const int timeout = 10000;
char menuOption = 0;
long time0;

void setup()
{

    Serial.begin(9600);
    while (!Serial) ;
    Serial.println("start");

    wifi.init(SSID, PASSWORD);
    menuOption = menu();

}


void loop()
{


    if(menuOption == '1') {
    wifi.httpGet(host, hostPort);
    char* wifiBuf = wifi.getBuffer();
    char *wifiDateIdx = strstr (wifiBuf, "Date");
    for (int i = 0; wifiDateIdx[i] != '\n' ; i++)
```

Figure 3: Sample code for the microcontroller and the setup

```
char menu()
{

    Serial.println(F("\nWhich component would you like to test?"));
    Serial.println(F("(1) ESP8266-01 - Wifi Module"));
    Serial.println(F("(2) QuadBand GPRS-GSM SIM800L"));
    Serial.println(F("(3) Soil Moisture Sensor"));
    Serial.println(F("(4) Submersible Pool Water Pump"));
    Serial.println(F("(5) This Analog Temprature Sensor can measure -40
    Serial.println(F("(6) Water Level Sensor Module"));
    Serial.println(F("(menu) send anything else or press on board reset
    while (!Serial.available());

    // Read data from serial monitor if received
    while (Serial.available())
    {
        char c = Serial.read();
        if (isAlphaNumeric(c))
        {

            if(c == '1')
          Serial.println(F("Now Testing ESP8266-01 - Wifi Module"));
        else if(c == '2')
          Serial.println(F("Now Testing QuadBand GPRS-GSM SIM800L - note
```

Figure 4: Necessary code

Figure 3 and figure 4 above shows the sample and necessary codes that need to make the set of the sensor layer. Once the setup is done, the data is merely passing to the real-time cloud database for further operation

4.2 Cloud real-time database – Cloud layer

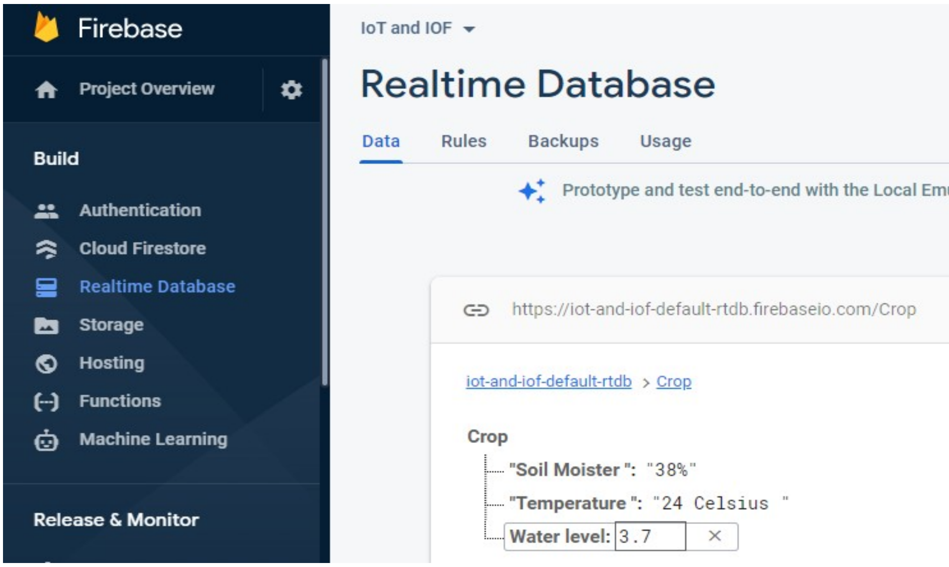

Figure 5: Real-time database

Figure 5 clearly illustrates the data passing to the cloud database with the Wi-Fi module's help connected with the microcontroller. The sensor continuously monitors the changes in the environment and update the cloud database as in figure 5.

4.3 Mobile layer

Figure 6 and figure 7 below shows the developed android app for crop monitoring. When we look at figure 6, the app shows the exact value which stores in the firebase cloud database. Whenever any parameter changes and needs a severe operation, the crop app provides the action message in figure 7. Also, whenever other parameter changes with a threshold value, the farmers can get the notifications promptly. They can do the needed action on time. This whole operation will helpful to the farmers to ensure precision agriculture without any suspicions.

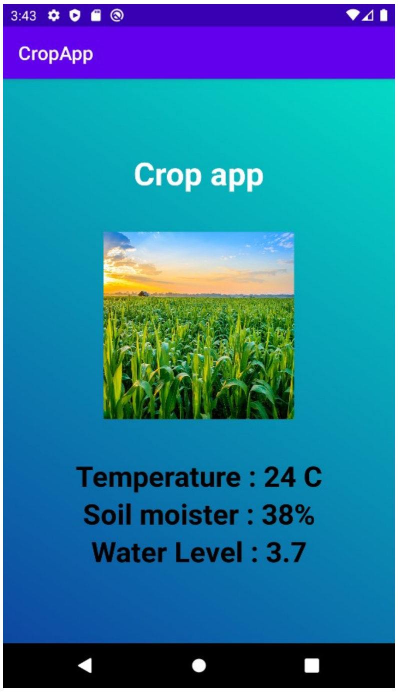

Figure 6: Mobile app with crop monitoring

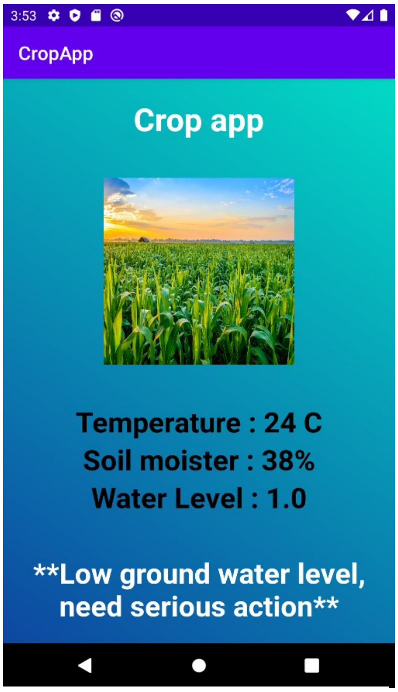

Figure 7: Warning structure of the crop app

5 Conclusion

A microcontroller takes on the role of being the regulator of an IoT system. The sensors play a vital role in IOF. All environmental and crop changes are monitored continuously with the necessary sensors. A further exciting observation recognized during the study is, dealing with IoT is very cheap and efficient. Albeit we have significant advantages using IoT in precision agriculture, privacy is always considered an unsolvable puzzle. When the proposed prototype is implemented with proper technique, the farmers will get higher advantages. Nowadays, a machine learning technique delivers a comprehensive solution in the agriculture field by identifying the disease. The best neuromorphic solution for precision agriculture is to combine information going into the IoT with a machine learning technique for plant disease implementation.

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