e-Agriculture: Irrigation System based on Weather Forecasting

Koppala Guravaiah
Department of Computer Science & Engineering,
Indian Institute of Information Technology Kottayam
Kerala, India
Email: kguravaiah@iiitkottayam.ac.in

S Srinivasulu Raju
Department of Electronics & Instrumentation Engineering,
Velagapudi Ramakrishna Siddhartha Engineering College,
Andhra Pradesh, India
Email: srinu85raju@gmail.com

2020 IEEE 15th International Conference on Industrial and Information Systems (ICIIS) | 978-1-7281-8524-8/20/$31.00 ©2020 IEEE | DOI: 10.1109/ICIIS51140.2020.9342739

***Abstract*—Internet of Things (IoT) is an emerging area to assist agriculture related applications. Applications such as smart gardening, water maintenance, other equipment automatic installations based on human actions, etc., can be implemented using IoT. In this paper, a wireless sensor based networking system is proposed to address water pumping system to crop and feed nutrients to crop. The first problem is to automate the process of pumping the water to crop in a garden. Temperature and humidity sensor are used to monitor the temperature in order to initiate the water pumping system, while soil moisture sensors are used for sensing the water level and initiate the process of pumping the water to the crops in the garden. Rain sensor is used to check the rain, if rain is coming it is going to stop all the motors. Second, liquid nutrients will be given to crop with water pumping system using venturi injector. River Formation Dynamics based data collection is applied to collect and store the information in server for further processing. Proposed systems are deployed and demonstrated using open-source hardware such as micro controller, GSM, etc.**

Keywords*—Internet of Things, Wireless Sensor Networks, Routing Protocols, Data Collection, River Formation Dynamics, Temperature sensor, Humidity sensor, Soil moisture sensor, venturi injector, rain sensor, RFDMRP.

I. Introduction

The new emerging area "Internet of Things (IoT)" is applied in almost all sort of applications [1], [2], [3], [4] such as Home monitoring, structural monitoring, vehicle monitoring, medical applications, and pursuing for military applications, etc. Currently, most of the people are concentrated on Agriculture with the IoT applications can be called it as e-Agriculture, with the aim to improve the productivity with less human effort. In e-Agriculture, one of the main steps is watering the plants whenever they require, without wastage of much water. To achieve this there are so many approaches came into the existence. Even though there exist some improvement, which require to the existing approaches.

According to World bank (*https://www.worldbank.org/en/topic/water-in-agriculture*), 33% of population throughout the world are experiences water scarcity. It is going to increase up to 50% by year 2030. Approximately 70% of absolute volume of water extractions on the planet are utilized for irrigation system. This exposes the significance of smart irrigation controlled by the IoT that can go for in dealing with the soaring water quantity around the world.

From last decade, researchers have proposed many techniques using different technologies with the help of internet services to achieve e-agriculture. This paper main focus is to propose a technique to reduce water wastage in agriculture and provide liquid nutrients to the roots of each plant by automating the drip system in a very smart and easier way. The motivation of the paper to achieve the above as follows:

- To reduce water wastage in agriculture using soil moisture sensor, rain sensor, temperature & humidity sensor
- Usage of Venturi injector to supply liquid nutrients to roots

The paper is organized as follows: Section II describes the associated work and issues in existing systems. Details of Software and Hardware used in the proposed system presented in Section III. Proposed system with real time implementation are discussed in Section IV. Finally, Section V Discuss the conclusions and issues of the paper.

II. Related Work

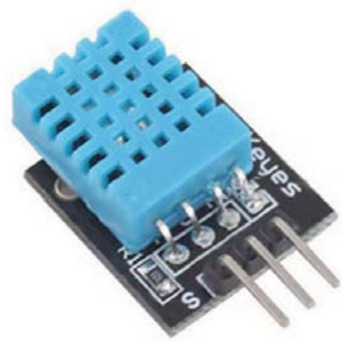
During the most recent decade scientists have widely investigated various applications for e-agriculture utilizing different microchip and miniature regulator sheets, for example, Raspberry Pi, Arduino with various sensors, for example, temperature, humidity, moisture, etc.

Smart irrigation monitoring and management system integrated with mobile using internet of things [5] is proposed to control the water supply and monitoring the gardens using a smart phone.

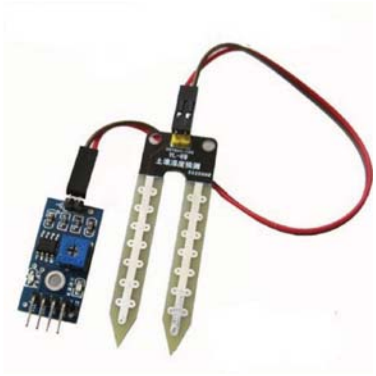
Yuthika Shekhar et al. [6] implemented the Intelligent IoT based Automated Irrigation system in 2017. In this work, temperature and soil moisture data are caught and machine learning based K- Nearest Neighbor classification algorithm is employed for examining the sensor information for forecast towards irrigating the soil with water.

In the year 2017, Dishay Kissoon et al. [7] proposed Smart Irrigation and Monitoring System. In this work, sensors collects humidity and temperature of air, and soil moisture data. This data will be useful for monitoring of air quality and water content in the soil.

Smart farm irrigation system is proposed by Shweta B. Saraf and Dhanashri H. Gawali [8]. This proposed system performs remote monitoring and controlling of drips through



(a) Temperature & Humidity Sensor



(b) Soil Moisture Sensor

(c) Rain Sensor

(d) Venturi Injector Device

(e) GSM Device

(f) Raspberry Pi Micro-processor

Figure 1: Boards used in proposed model

wireless sensor network using android phone. In addition to this, sensor nodes and base station are communicated with the help of Zigbee.

In e-Aggriculture, until today the researchers concentrated on agriculture with different sensors and it's computational complexities [9], [10]. Difficulties present in literature are as follows:

- Fertilizer distribution for crop is not automated.
- Water distribution system is not connected with rain, due to this wastage of water will be more.
- Efficient Data collection routing protocols is required for data collection.

This paper concentrates on a simple e-agriculture application to monitor water level and provide fertilizers using temperature, soil moisture sensor, and rain sensor with less cost.

III. Requirement Specifications

This Section will presents the diverse software and hardware components used in the proposed system.

A. Temperature & Humidity Sensor

Temperature & Humidity sensor [11] is present in Fig. 1a used to capture temperature and Humidity from specific sources and modify the collected information into understandable format for the user. Temperature & Humidity sensors are used in several applications namely chemical handling, medical devices, food processing units, environmental controls, controlling systems, etc.

B. Soil Moisture Sensor

Soil Moisture Sensor [12] present in Fig. 1b will measure the volumetric water substance in soil or land. The soil moisture is sensed using copper electrodes. Measurement of moisture content level is calculated using conductivity between the electrodes. This sensor will be useful for measuring soil moisture in different applications such as soil science, horticulture, botany, environmental science, agricultural science, and biology.

C. Rain Sensor

Rain sensor is activated by rain fall is shown in Fig. 1c. This sensor will work like a switch. If rainfall is there switch will be closed if there is no rainfall then switch will be open.

Part No: CFP2058A-ART; ISBN No:978-1-7281-8524-8/20

D. Venturi Injector

Venturi injectors (shown in Fig. 1d) are used to mixing gases or liquids into a stream of water and spray on crop. This venturi injectors works on differential pressure principle. Pressure vacuum will be created due to the pressure generated in the entry and exit points. These injectors use to take from a tank small amount of fertilizer and sends it into waterline.

E. GSM

A second-generation cellular network (2G) also called as GSM or Global System for Mobile communications [13] present in Fig. 1e. In this paper GSM can be used as a Simple Message System (SMS or text messaging) to transmit the messages to owner using data communication.

F. Raspberry Pi Micro-processor

Raspberry Pi [14] Model B is used as a microprocessor in proposed model is shown in Figure 1f.

Raspberry Pi is employed as a personal computer by interfacing Monitor through HDMI, keyboard and mouse associated through USB. There are two operating systems namely Debianbased Raspbian and Linux Distro are going to support for Raspberry PI. Proposed system is going with Raspbian operating system

G. RFDMRP: River Formation Dynamics based Multi-hop Routing Protocol

To collect the data generated by sensor will be transferred using River Formation Dynamics based Multi-hop Routing Protocol (RFDMRP) [15], [16] for collecting the data from agriculture fields and sending to BS for further processing.

IV. Proposed Model

A few kinds of sensors are utilized to parlay information to the water system multi-regulator unit. Every unit is devoted to sense and send explicit information. The primary of the units is that the soil moisture sensor, which inspects the current agricultural observing framework has applied faraway sensors for checking the dust situation for the water system. In none of these frameworks are having expertise in investigation of continuous information beyond the watering sector. The greater part of these framework just catches the records from the field and as needs control the sprinkler valve for watering the field. This section concentrated on the issues faced by the exiting systems and proposes a efficient use of Internet of Things to focus on the issue of water usage for irrigation and nutrients to plants using venturi injector.

A. Proposed System Architecture

Wireless sensor network system may be a mix of different equipment parts and programming modules. Fig. 2 shows the recommended system architecture for Agriculture. The proposed system contains a micro-processor (μP) connected with different sensors as Temperature & Humidity, Soil moisture sensor, DC motor, and a GSM module. The proposed system is going to monitor agriculture field based on the environmental conditions. If soil moisture is less and temperature is high or no rain is there in the field then the proposed system is going to alert the system to pump the water. Same details are going to send to server for further processing.

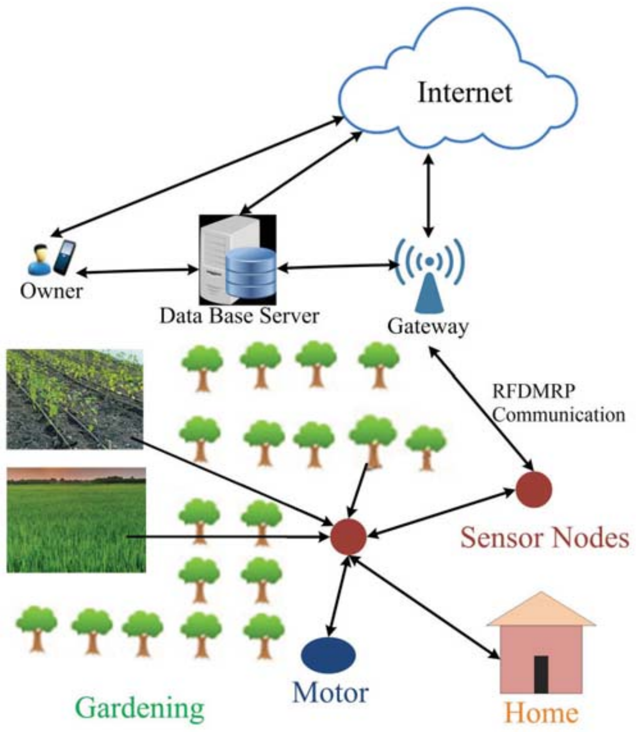


Figure 2: Basic model of proposed approach

In the recommended system as shown in Fig. 3 with different sensors connected with microprocessor will perform the following operations:

- **Temperature & Humidity Sensor:** This sensor will calculate the environment and soil temperature. Microprocessor will take this temperature value check for switching on the motor to drip the water on ground or garden. Additionally, send this information to store for future prediction & analysis purpose.
- **Rain Sensor:** This sensor is useful to detect the rain. When rain is started then this sensor will instruct to automatic irrigation system to stop motor and all other devices, due to rainfall.
- **Soil Moisture Sensor:** Soil moisture sensor will sense the soil of the garden. If water level is less then soil moisture sensor will send the details to microprocessor to activate the GSM to send the message to the owner and start the motor to water the plants in the garden using drip system.
- **Venturi Injector:** Fertilizers will add strength to sustain from crop plagues or other insects. Fertilizers are distributed with the help of dripping system is implemented with the help of venturi injector. Same information is stored in the server for later analysis.

The Process flow diagram of proposed approach is shown in Fig. 4.

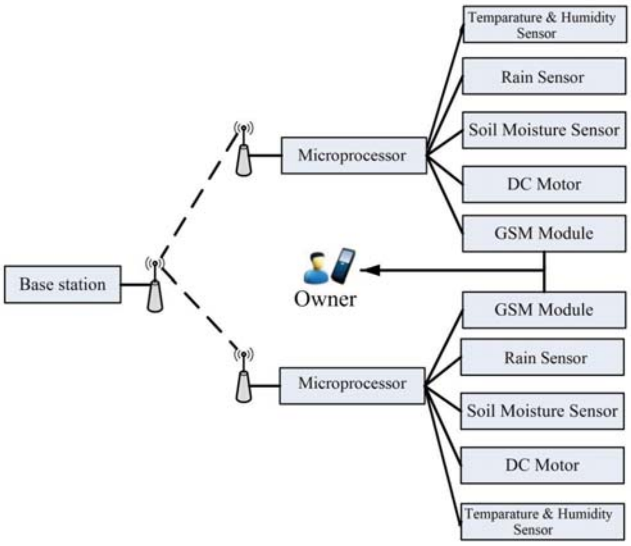


Figure 3: Schematic Diagram of Proposed System

Algorithm 1 Proposed algorithm

```
procedure Proposed_Algorithm()
    H = HIGH, L = LOW
    while 1 do
        if (rain == H) then
            Turn off  motor
            Send information to server using RFDMRP
            Send SMS to owner
            return
        end if
        if (Soil_moisture == L)or(Temp == H) then
            if (isFertilizerRequire) then
                Turn on  motor & venturi injector to water the
                plants with fertilizers
            else
                Turn on  motor
            end if
            Send Soil Moisture Sensor & Temperature details to
             server using RFDMRP
            Send SMS to owner
            return
        end if
    end while
end procedure
```

B. Proposed Algorithm

Whenever temperature sensor values are high and soil moisture value is low, an SMS will be sent to the owner of the land as well as motor is turned on to pump water in order to increase the water level as shown in Algorithm 1. If rain is started this system is going to stop motor and other devices due to rainfall. Same information about rainfall is transmitted to server. Whenever fertilizers are required with the use of venturi injector, we can inject to plants. Same time these values are collected by using RFDMRP data collection protocol and send to server for storing and further processing.

Algorithm 2 RFDMRP algorithm

```
procedure RFDMRP()
    node_Deployment()
    Routers_NNTable_Creation()
    EndDevice_NNTable_Creation()
    while 1 do
        Sense the data
        unicast the packets to router or server on detecting
        sensor values
        repeat
            Router will unicast the Sensor values using
            RFDMRP to neighbor routers or server
        until data reaches server
    end while
end procedure
```

Table I: Cost of proposed work without additional server

Sl. No.	Items	Cost (in Rupees)
1	Microprocessor	2800
2	GSM Module	1500
3	Rain Sensor	100
4	Temperature & Humidity Sensor	100
5	Soil Moisture Sensor	120
6	DC Motor Sensor	1000
7	Other expenditure for setup	2380
	Total	8000

V. Experimental Setup & Results

Whilst all of the sensors are integrated, we acquire two circuits one that draws the 230v strength supply i.e., motor and the sensors require 5v. Hence, optocoupler (Robotbanao JX-FRON-V4L7) acts as isolator that protects the circuit. In this when moisture level decreases to beneath 25% motor will ON, where water flows through venturi injector to drip pipes then comparable situations will manifest when the temperature reaches above room temperature, while the rain sensor detects the rain, and the gadget will automatically shut down. This is the operation of a clever irrigation system where we will supply liquid vitamins through phase pipe of venturi injector when essential.

The proposed system is tested with the help of Temperature & Humidity Sensor, Rain Sensor, Soil Moisture Sensor, DC Motor and one GSM devise connected to microprocessor. The setup is shown in Fig. 5, Fig. 6, and Fig. 7.

Fig. 8 shows the messages received from the microprocessor to the registered mobile phone based on the sensor values and threshold values of the sensors during the sensing time is also stored in database as shown in Fig. 9.

The cost of the experimental setup is shown in Table I.

A. Applications

The proposed system has the resulting Claims:

- Monitoring of garden or agriculture land for soil water content.

Part No: CFP2058A-ART; ISBN No:978-1-7281-8524-8/20

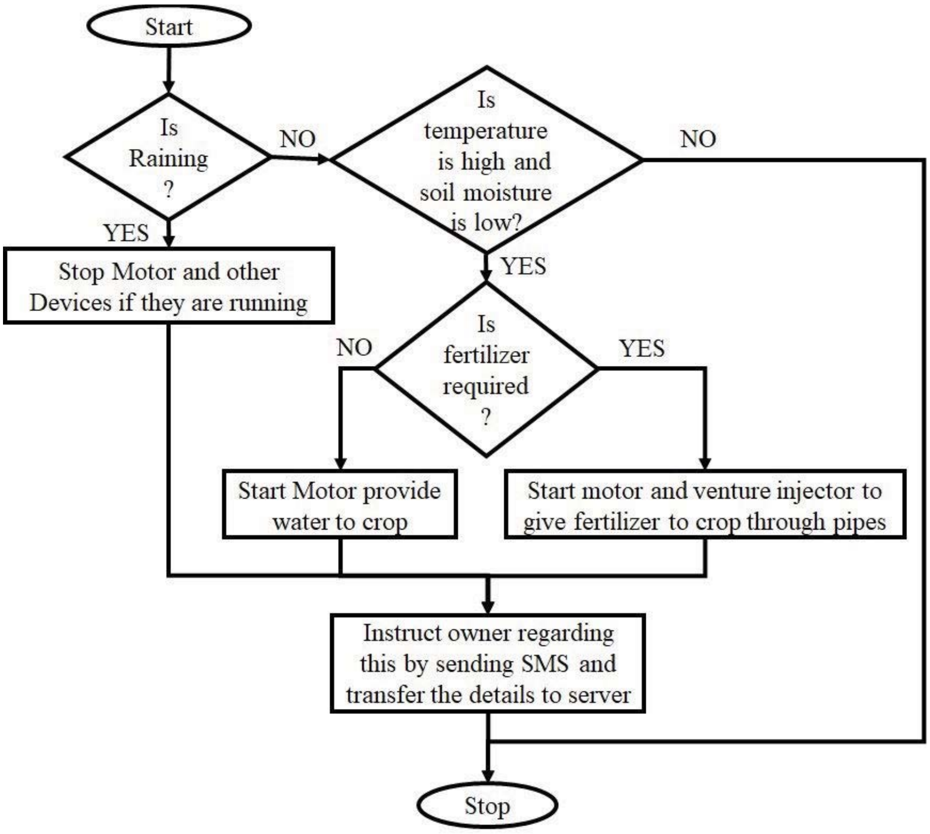


Figure 4: Process flow diagram of proposed approach

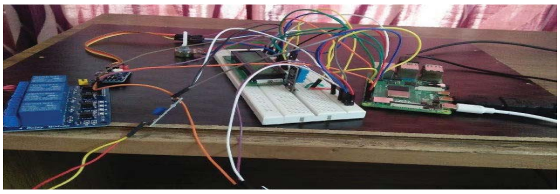


Figure 5: Circuit connections of the proposed model

Figure 6: Implementation system

- Injecting or keeping fertilizers whenever require without much human effort.
- Whenever rain is falling, system will switch off motor and other devices

B. Advantages

The following benefits are there for proposed system:

Figure 7: Overall Implementation system

- The proposed system is cost effective.
- The supervision of water system is controlled easily using the proposed system.
- Reduction of human effort while keeping fertilizers to land.
- Reducing the labor cost to the farmer.

VI. Conclusion

In this paper, an IoT based system is proposed to address the commonly occurring problem namely water wastage in agriculture. The proposed system is deployed and demonstrated in real time using open-source hardware platforms such as microprocessor, temperature, soil moisture, rain sensors, and GSM. In future, we are planing to deploy in real agriculture field to know the performance of the proposed system and planning to compare with other similar kind of systems. It can be extended by integrating with think speak software and

Part No: CFP2058A-ART; ISBN No:978-1-7281-8524-8/20

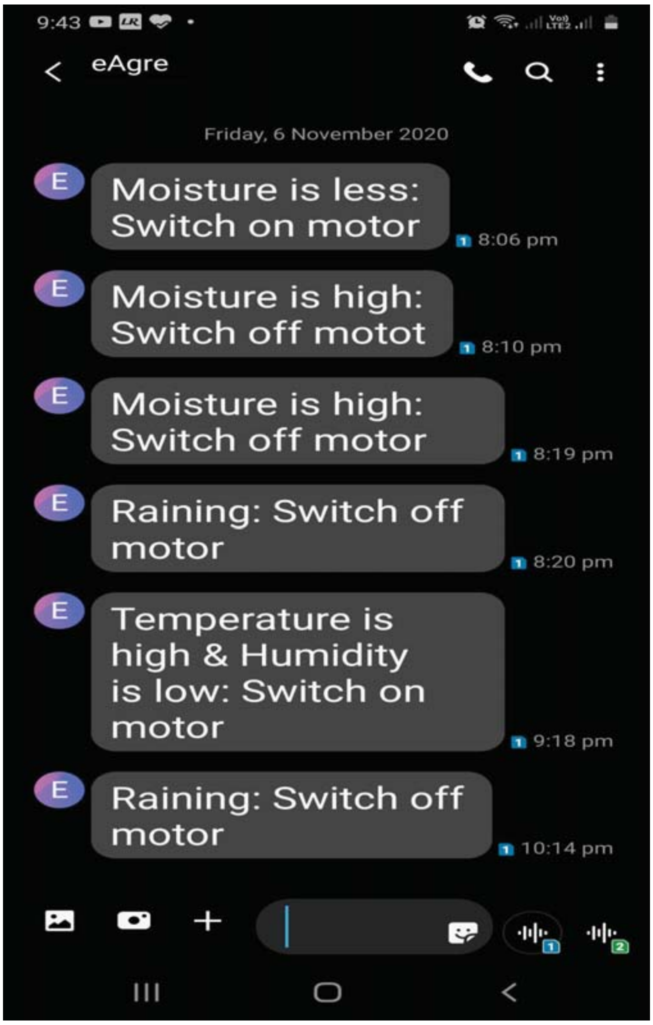


Figure 8: SMS received by Owner of the land

we can monitor through our mobile phone. Even integrate with weather monitoring satellite system For effective weather prediction and sensors work accord.


```xml
<?xml version="1.0"?>
- <root>
  - <eAgri>
      <Location>Cabin1</Location>
      <Temp>32</Temp>
      <Rain>0</Rain>
      <SoilMoisture>0.29</SoilMoisture>
      <Time>2020-05-28 12:01:0.570557</Time>
    </eAgri>
  - <eAgri>
      <Location>Cabin1</Location>
      <Temp>32</Temp>
      <Rain>0</Rain>
      <SoilMoisture>0.32</SoilMoisture>
      <Time>2020-05-28 12:16:1.075530</Time>
    </eAgri>
    ...
  - <eAgri>
      <Location>Cabin1</Location>
      <Temp>28</Temp>
      <Rain>1</Rain>
      <SoilMoisture>40</SoilMoisture>
      <Time>2020-06-01 19:01:1.012312</Time>
    </eAgri>
  </root>
```


Figure 9: Sample output collected and stored in XML database.jpg

References

[1] Shancang Li, Li Da Xu, and Shanshan Zhao. The internet of things: a survey. *Information Systems Frontiers*, 17(2):243–259, 2015.

[2] Sajjad Hussain Shah and Ilyas Yaqoob. A survey: Internet of things (iot) technologies, applications and challenges. In *2016 IEEE Smart Energy Grid Engineering (SEGE)*, pages 381–385. IEEE, 2016.

[3] Koppala Guravaiah and R Leela Velusamy. Prototype of home monitoring device using internet of things and river formation dynamics-based multi-hop routing protocol (rfdhm). *IEEE Transactions on Consumer Electronics*, 65(3):329–338, 2019.

[4] Koppala Guravaiah, Arumugam Kavitha, and Rengaraj Leela Velusamy. Data collection protocols in wireless sensor networks. In *Wireless Sensor Networks-Design, Deployment and Applications*. IntechOpen, 2020.

[5] S Vaishali, S Suraj, G Vignesh, S Dhivya, and S Udhayakumar. Mobile integrated smart irrigation management and monitoring system using iot. In *Communication and Signal Processing (ICCSP), 2017 International Conference on*, pages 2164–2167. IEEE, 2017.

[6] Yuthika Shekhar, Ekta Dagur, Sourabh Mishra, and Suresh Sankaranarayanan. Intelligent iot based automated irrigation system. *International Journal of Applied Engineering Research*, 12(18):7306–7320, 2017.

[7] Dishay Kissoon, Hinouccha Deerpaul, and Avinash Mungur. A smart irrigation and monitoring system. *International Journal of Computer Applications*, 163(8), 2017.

[8] Shweta B Saraf and Dhanashri H Gawali. Iot based smart irrigation monitoring and controlling system. In *Recent Trends in Electronics, Information & Communication Technology (RTEICT), 2017 2nd IEEE International Conference on*, pages 815–819. IEEE, 2017.

[9] S. Suresh, J. Bhavya, S. Sakshi, K. Varun, and G. Debarshi. Home monitoring and security system. In *2016 International Conference on ICT in Business Industry Government (ICTBIG)*, pages 1–5, Nov 2016.

[10] S. R. Prathibha, A. Hongal, and M. P. Jyothi. Iot based monitoring system in smart agriculture. In *2017 International Conference on Recent Advances in Electronics and Communication Technology (ICRAECT)*, pages 81–84, March 2017.

[11] Temperature Sensor, available at, http://playground.arduino.cc/main/dhtlib/, 2020. [Online; accessed 5-November-2020].

[12] Soil Moisture Sensor, available at, https://en.wikipedia.org/wiki/soil_moisture–sensor/, 2020. [Online; accessed 5-November-2020].

[13] GSM Device, available at, https://www.arduino.cc/en/guide/arduinogsmshield, 2020. [Online; accessed 5-November-2020].

[14] Raspberry Pi, available at, https://www.raspberrypi.org/, 2020. [Online; accessed 5-November-2020].

[15] Koppala Guravaiah and R Leela Velusamy. Rfdmrp: River formation dynamics based multi-hop routing protocol for data collection in wireless sensor networks. *Procedia Computer Science*, 54:31–36, 2015.

[16] Koppala Guravaiah, RG Thivyavignesh, and R Leela Velusamy. Vehicle monitoring using internet of things. In *Proceedings of the 1st International Conference on Internet of Things and Machine Learning*, pages 1–7, 2017.