International Scientific Journal of Engineering and Management
ISSN: 2583-6129
Volume: 02 Issue: 05 | May – 2023 DOI:
www.isjem.com
An International Scholarly || Multidisciplinary || Open Access || Indexing in all major Database & Metadata

Use Of Digital Technology For Micro Irrigation System To Improve Water Efficiency Of Irrigation Sector(Using IoT, ML and Cloud Computing)

Shivam Kishor Patange[1], Rushikesh Madhav Sagare[2], Shivam Govindrao Mahalanakar[3], Assistant Prof. Sachin Trankatwar[4]

[1]Shivam Kishor Patange, Electronics and Telecommunication Engineering, VPKBIET, Baramati
[2]Rushikesh Madhav Sagare, Electronics and Telecommunication Engineering, VPKBIET, Baramati
[3]Shivam Govindrao Mahalankar, Electronics and Telecommunication Engineering, VPKBIET, Baramati
[4]Assistant Prof. Sachin Trankatwar, Electronics and Telecommunication Engineering, VPKBIET, Baramati

---***---

Abstract - The bulk of the people in India is dependent on agriculture. Due to climate change and the steady loss of natural resources, water resources should be used for farming in an effective and exact manner. By suggesting an Internet of Things (IoT) based system for automated smart drip irrigation and monitoring, this research aims to automate the laborious operation. With the aid of sensors, it will decide whether and when to turn on or off the watering pump and water flow through drip irrigation in accordance with weather, soil, and crop conditions. This has the ability to regulate the amount of moisture in the cultivating field's soil.This has the ability to regulate the amount of moisture in the cultivating field's soil. The Idea is to create such a solution which will be able to collect, store and process the environmental values to make decision depending upon them respectively. Initialising with sensing the moisture and humidity values using the sensors. Which will send those values to the cloud via IOT technology, which will be processes there. And finally decided whether to turn on or off the motor. This will provide an efficient as well as long term solution for this problem.

Key Words: Drip Irrigation, IoT, NodeMCU, ESP8266, ML, Decision, Cloud Computing

1. INTRODUCTION

Traditionally, drip irrigation farming has been performed manually, which requires the farmer to be physically present in the field. In agriculture, the major problem faced by Indian farmers is water scarcity, which is becoming a critical issue. In addition, there are quite a few areas in our country that also face drought. To improve the usage of water, an accurate amount of water required by a particular crop must be provided only at the time it needs.

This solution proposes a "Automated Drip Irrigation System using ML, IoT and Cloud Computing". Our Sensors will detect the moisture values from the soil and send them to the cloud platform using a NodeMCU ESP8266 microcontroller (which will be responsible for all the communication and controlling actions) unit and from the cloud where we will run our Machine Learning algorithms to train our model and send the instructions back to the microcontroller and switching unit, which will be responsible for the switching of the watering motor as per the soil condition.

2. Drip Irrigation

A. Working

Farming in India is done various irrigation methods which involves

•Surface Irrigation
•Localized Irrigation
•Sprinkler Irrigation
•Drip Irrigation
•Centre Pivot Irrigation
•Sub Irrigation
•Manual Irrigation

Out of these drip irrigation is found to be most suitable as well as water efficient if compared to others, in Indian weather conditions and Indian crops like fruits and vegetables. In drip irrigation water and nutrients are allowed to drip slowly in to the root zone of the soil. The pipes are laid across the field and these pipes have holes in them after a some distance which makes sure the water should drip close to the root which minimizes evaporation.

B. Problem

Even after being so advanced and water efficient it still has some problems such as, when the motor starts pumping water into drip irrigation pipes the farmers have to be there to make sure if the water has reached to last crop in the field. operator often have no idea if the provided water is sufficient for that particular crop or not which ends up being either under-watering or over-watering the crop. Under-watering will result in insufficient nutrition to the plants whereas over-watering will wash out nutrients from the soil. This clearly shows the absence of automation as well as machine intelligence in the irrigation sector and creates a room for automation, monitoring as well machine intelligence.

3. Literature Review

When it comes to agriculture, the majority of farming uses traditional methodologies; however, in modern times, the world is moving toward newer technologies, including India. This revolution in agriculture was accompanied by the introduction of micro-irrigation and drip systems. This revolution was later contributed by many individuals and

International Scientific Journal of Engineering and Management ISSN: 2583-6129
Volume: 02 Issue: 05 | May – 2023 DOI: www.isjem.com
An International Scholarly || Multidisciplinary || Open Access || Indexing in all major Database & Metadata

organizations. In 1977-78 J. Doorenbos and W. Pruitt published guidelines for predicting crop water requirements in the Food and Agriculture Organization (UN), Rome. Later in 1986-87 Brouwer, C., Heibloem published Irrigation Water Management, Training manual which was focused on effective ways of water management in the Irrigation field. These Two studies have helped many people and researchers to understand effective water management in the irrigation sector.

Later in 2016-17 G. Kavianand and S. Lalitha, published a research on Smart Irrigation system for sustainable agriculture in IEEE Technological Innovations in ICT for Agriculture and Rural Development (TIAR), Chennai. This is useful for understanding the automation in agriculture. But it was not enough as the world was moving towards the Internet of Things era, this technology had a huge scope in the agriculture field as well So in 2018-19 D. Mishra, A. Khan, R. Tiwari and S. Upadhyay published research on the Automated Irrigation System-IoT-based Approach at the 3rd International Conference on Internet of Things Smart Innovation and Usages (IoT-SIU), Bhimtal, which effectively gathered agriculture and the IOT under the same umbrella and demonstrated how it can be done, which was a major leap in both the agriculture and IOT domains.

But then in 2021 Shilpa Chandra, Samiksha Bhilare, Mugdha Asgekar and Ramya R. B. Published a research on Crop water requirement prediction in automated drip irrigation system using ML and IOT in IEEE Technological Innovations in ICT for Agriculture and Rural Development (TIAR), Chennai which used a ML based approach which was not just a emerging technology but also way more effective, adaptable and reliable alternative over hard coded if-else conditions, this research was one of the major motivation for this solution.

4. Motivation

Despite the many advantages of micro-irrigation systems, there is still room for improvement in terms of automation and smartness. The micro-irrigation system is efficient but lacks in terms of deciding the right amount of water or when to start and stop watering, making it completely manual, labor-based, and unsupervised. Due to the unsupervised use of the water in the irrigation, not only do the crops suffer from excess watering, but also the water source undergoes depletion; however, water is wasted, which may lead to the scarcity of water after a period of time. We need a solution that can not only monitor and supervise the soil contents, but also suggest when to stop and start watering.

We are proposing a system which will be motoring the soil contents such as moisture levels but also will be able to control the motor switching upon such instructions. In this solution, we employed technologies such as IoT, Cloud Computing and Machine Learning to achieve the optimum performance of our solution.

5. Proposed System

This paper proposes a system which will extract the moisture data from the soil environment using FC-28 Soil Hygrometer (Moisture) Sensor and send that data to the AWS's Ubuntu cloud based Machine Learning model using NodeMCU ESP8266 microcontroller. The Machine Learning code will classify those values and classify that soil data as either dry or wet by referring a certain threshold set as 0.5 and depending upon the that send back a signal to the NodeMCU ESP8266 microcontroller to either turn on or turn off the watering motor.

A. Hardware Components

The hardware components used in this solution can be classified in to types as Sensor, Microcontroller and Switching unit.

a. Sensors

The sensor used in this solution is FC-28 Soil Hygrometer (Moisture) Sensor. FC-28 Soil Hygrometer (Moisture) sensor is used to measure the moisture present in the soil is terms of percentage. Both terminals of the sensors are kept in the soil, then the microcontroller passes current through one terminal and measures the resistance between the two terminals and using returns the soil moisture in form of digital values ranging from 1023 to 0. 0 being completely wet as it is showing zero resistance to the current flowing through the terminal while 1023 indicates completely dry state as no current passed from one terminal to other.

b. Microcontroller

The microcontroller used in this solution is NodeMCU ESP8266 which has an inbuilt Wi-Fi technology used for communication both in local as well public networks. The NodeMCU ESP8266 will convert the sensed moisture values ranging from 0 to 1023 on the scale of 0 to 1. 0 being completely dry and 1 being completely wet and other values will lie in between using map() function in the embedded C. In this solution NodeMCU ESP8266 is employed due to its Wi-Fi capabilities. Using Wi-Fi connectivity the NodeMCU ESP8266 will public collected moisture data to the AWS based cloud platform. Also receive the decisions from the cloud platform and implement them on the switching circuits of watering motor.

c. Switching Unit

The switching unit for switching the water motor in this solution is 5V relay switch. Which is an affordable and microcontroller controlled switch used for switching high voltage applications. It is similar to other switches as it read 0 as Low which opens the circuit (Breaks the Connection) and 1 as High which closes the circuit (Connects the Circuit). It works on 5V supply which can be provided from any available power supply system or microcontroller itself. But in this solution as the maximum output current provided by

International Scientific Journal of Engineering and Management
Volume: 02 Issue: 05 | May – 2023 DOI:
ISSN: 2583-6129
www.isjem.com
An International Scholarly || Multidisciplinary || Open Access || Indexing in all major Database & Metadata

the NodeMCU ESP8266 is 3.3V, We need to provide an external 5V DC supply to the 5V relay switch. Switching digitally using binary input as '1' and '0' makes it an ideal choice for our solution. When the decision about the switching is generated and published from the cloud, it is directly reflected on the NodeMCU ESP8266 microcontroller which can feed it to the 5V relay switch to either turn on or off the switch. Also its working voltage is 5V which is easily available on our work bench.

B. Software Components

The software components used in this solution are spreads all the way from programming the microcontroller to the cloud in designing the machine learning model to the establishing an MQTT server over there for communication and exchange of messages. Some of the key software components used in this solution are AWS EC2 Cloud for cloud computing, Linux Ubuntu as operating system on the cloud platform, Decision Tree Classification as Machine Learning Algorithm for classification of moisture values as wither wet or dry, etc.

a. AWS EC2 Cloud

The Amazon's AWS provides exclusive services to the cloud computing needs. Its is subsidiary of Amazon that provides on-demand cloud computing platforms and APIs to individuals, companies, and governments, on a metered pay-as-you-go basis. In this solution we are using AWS's EC2 due to its elastic and nature and affordability. Our need for this solution lies perfectly in the spectrum of EC2's offerings. We barely need 2GBs of RAW memory, and 20GBs of on cloud storage space to put and run our machine learning model. Due its simplicity and availability AWS's EC2 became our prime choice.

b. Linux Ubuntu

Linux Ubuntu is a Debian based linux distribution considered best for the cloud based applications. Ubuntu is widely famous for its simplicity and usability in the server arena so it is widely used. Ubuntu in written in C and is capable of running many programming languages such as Python3, Ruby, etc. Which is essential for our solution to run our machine learning model. Also Ubuntu is ideal choice for IoT applications due to its open source nature and ease of implementing MQTT protocol communication. So Linux's Ubuntu became a key point in this solution.

c. Decision Tree Classification

The Decision Tree Classification algorithm is supervised machine learning algorithm used for both classification as well as regression. The Decision Tree algorithm uses a set of input parameters for its training which can CSV files, etc. and the predict output based on provided test input. Here in this research we used experimental moisture values for classifying its nature either as dry or wet. These experimental values are collected using FC-28 Hygrometer Soil (Moisture) sensor. Decision Tree has many applications in classification as well regression and also has great accuracy in predictions.

C. Working

The working of the proposed system can be broadly classified into two sections as Hardware Design and Software Design.

a. Hardware Design

This project senses the environmental values from the ground level and begins by sensing the moisture values using a moisture sensor, which will be placed in the soil for collecting the moisture-related data, which will be in the form of numbers ranging from 1024 to 0. 1024 represents the soil being totally dry, while 0 represents complete current flow and negligibly low resistance between the terminals of the moisture sensor, representing a soil being very wet. Then, the NodeMCU ESP8266 collected the sensed moisture values and converted them from 0 to 1(0 being completely dry(1024) and 1 being completely wet(0)) using a map.

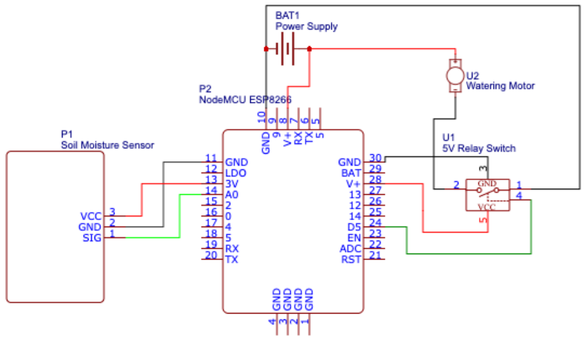

Figure 1: Hardware Design

After collecting moisture values ranging from 0 to 1, The NodeMCU ESP8266 microcontroller sends these values to the cloud platform using the WiFi network. WiFi needs to have an active Internet connection to receive those values on the cloud platform. Once the decision has been made and sent back to the NodeMCU ESP8266, it will turn off the 5V relay switch. The 5V relay switch is a relay-switching device that normally operates in the N0 and NC modes. A watering motor pump is used to pump water from the water source and provide it to the crops. Upon making a decision, the cloud server sends that decision back to the NodeMCU board, which is used to either turn on or off the motor. This ensures that the soil remains moist and intelligently provides appropriate water to the crops.

b. Software Design

In the software design process, we begin by receiving moisture values from the microcontroller on the cloud platform. Our cloud platform hosts the brain of our overall project, which is a decision-tree algorithm. We will use Linux

International Scientific Journal of Engineering and Management ISSN: 2583-6129
Volume: 02 Issue: 05 | May – 2023 DOI: www.isjem.com
An International Scholarly || Multidisciplinary || Open Access || Indexing in all major Database & Metadata

based Ubuntu operating system on the cloud for running our Decision Tree machine learning algorithm using Python3.

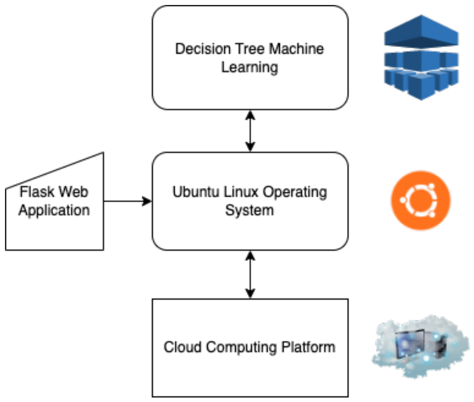

Figure 2: Software Design

The software part starts by receiving the moisture values from the NodeMCU ESP8266 microcontroller module to the cloud platform. The NodeMCU ESP8266 will publish the sensed values on topic "inTopic" of "Mosquitto MQQT" service running on the same cloud platform. Then the "inTopic" topic will be used to retain those values to our Decision Tree machine learning algorithm. The Decision Tree machine learning algorithm, written in Python3, decide whether to turn the water pump on or off depending on the soil condition. Once the Decision Tree ML file is decided in the form of either 1(for on) or 0(for off) on the topic "outTopic." This will be subscribed by the NodeMCU ESP8266 microcontroller, and depending on either 1 or 0, the NodeMCU ESP8266 will turn on or off the water pump, respectively.

After confirming the automatic working of the proposed cloud based system, There is still a room for manual control, suppose the user wants to turn off the motor regardless of soil condition, let's say it is dry. The moisture sensor along with whole cloud based setup including the ML will find it dry and as per the programming it will try to turn on the motor to make it wet and achieve moisturised condition. But suppose the well which is being used to pump water has ran out of water and became bone dry. In this condition the motor will definitely get burned to avoid this and bring human supervision in the project we need to have a manual control unit which will reside above the automatic system. To achieve we are using a python based Flask Web Application which will be able to manually turn on, off the motor and set it either in manual mode or back to the automatic mode as per the input from the user.

6. Data Collection

The database used for this project is purely experimental. The moisture values databases for this project has been collected using experimentation in real time using soil moisture sensor along with date-time timestamp and irrigation status from 2023-04-13 08:00:35 to 2023-04-16 10:11:08. A total of 104731 moisture values were recorded and used to train the decision-tree ML algorithm. The ML model uses all these moisture values and irrigation status to predict whether to turn on or off the watering pump upon feeding the moisture values.

Figure 3: Moisture Values Collection In Real Time

In the graph figure below the moisture values are mapped with respect to the time it was recored. At certain points the moisture surges up in the graph that point is the time when the irrigation is started (watering pump) till the soil gets sufficiently wet.

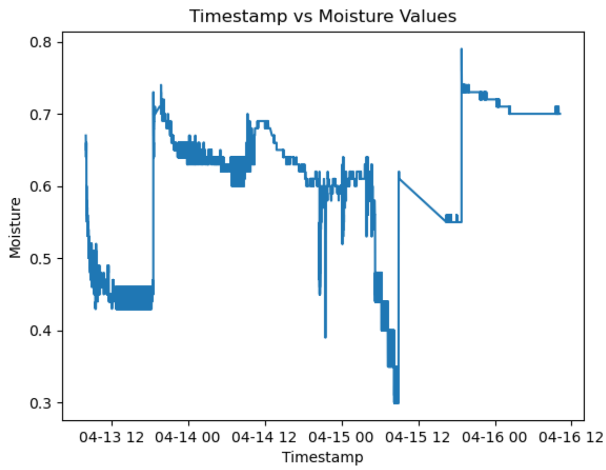

Figure 4: Moisture vs. Timestamp Graph

In the figure above the collected moisture data is represented in the graph with respect to when its collected.

7. Result

A.Software Simulation

The machine learning model is trained using the experimental data set values. For simulation purpose the Decision Tree model is implemented in the Jupyter Notebook and also for calculating accuracy of the trained model. The total of 104731 values had been used to train the machine learning model. Which include the time timestamp, moisture values (ranging from 0 to 1), irrigation status (1 for On and 0 for Off) and soil condition as either dry or wet (If moisture values is greater

International Scientific Journal of Engineering and Management ISSN: 2583-6129
Volume: 02 Issue: 05 | May – 2023 DOI: www.isjem.com
An International Scholarly || Multidisciplinary || Open Access || Indexing in all major Database & Metadata

than 0.5 wet and If less that 0.5 dry). The accuracy of the implemented model has been calculated using python libraries such as sklearn and train_test_split modules. The software simulation also includes successfully receiving decision messages from the cloud to the NodeMCU ESP8266 microcontroller. It can seen using the MQTT lens tool, which will be used to subscribe to the "outTopic" topic on the cloud's MQTT service and see the received message responses.

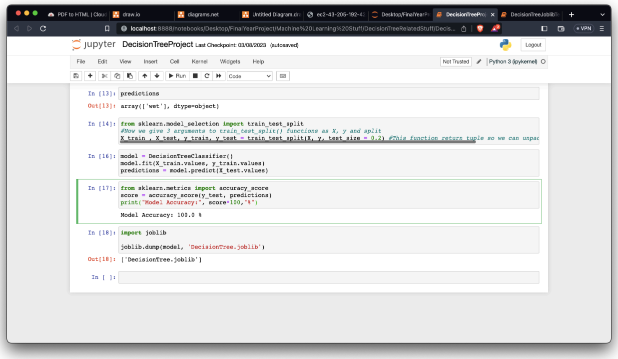

Figure 5: Accuracy of the Machine Learning Model

As in the figure above, the overall accuracy of the models predication has came to be 100%. That is due to we used only two parameters for training as moisture value and soil condition (Wet or Dry). This gives justification to the models accuracy.

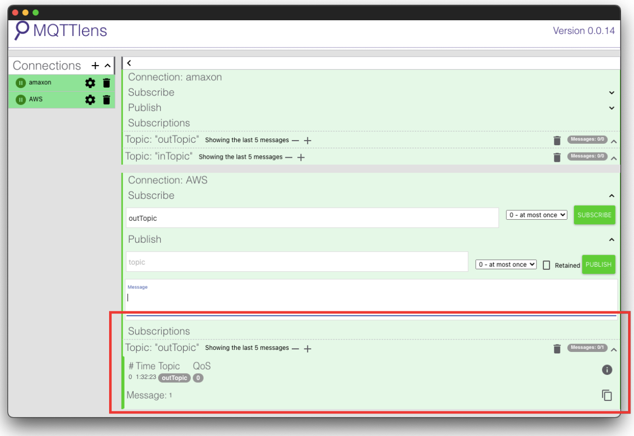

Figure 6: "outTopic" Message Received

In the figure above the message 1 has been received on the "outTopic" topic. So it is clear that the communication between the software part that is cloud and hardware part that is NodeMCU ESP8266 microcontroller is taking place as expected.

B. Hardware Result

The overall hardware including sensors, microcontroller and switching unit. By combining all of these as a single unit as per the schematics shown before completes the overall hardware part of this project.

So far majority of the work was located on cloud but actual application of the project lies on the ground. As planned in the hardware schematics all the components are successfully connected and all of them are up and running as the power supply is provided.

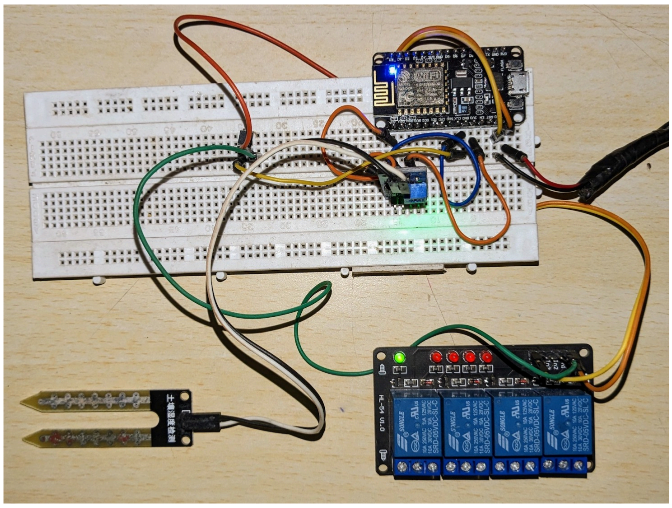

Figure 7: Hardware Implementation Result

As in the figure above LED's of NodeMCU ESP8266, FC-28 Hygrometer (Moisture) sensor and 5V relay switch are glowing which indicates the power has reached them and they are working as expected. When the probe of FC-28 Hygrometer (Moisture) sensor are dipped in the soil it started collecting moisture values and providing them to the NodeMCU ESP8266 microcontroller. The NodeMCU ESP8266 which is connected to the local Wi-Fi network will upload and publish those values on the 'inTopic' topic of the MQTT service running on the cloud platform. upon successfully making decision it will send back its decision to the NodeMCU ESP8266 microcontroller to either turn on or off the motor switch. Suppose the soil was dry and resulting decision is turn on then the NodeMCU ESP8266 microcontroller will implement that operation on the 5V relay switch circuit. In this hardware simulatio the hardware along with the software part was working and behaving as intended and expected.

CONCLUSION

The main purpose of this research is to provide a tool that farmers and cultivators may use to verify the compatibility of environmental conditions to boost crop growth and productivity in an efficient manner, resulting in the highest possible yield. Compared to the pricey soil testing equipment, this project provides virtually correct data. The model can be applied to any location. Once we upload the code in the microcontroller and on the cloud, it is not necessary to reprogram it later. Using this technology, many other projects can be conducted. By measuring the values of soil moisture, we can accordingly vary the amount of water needed to irrigate the soil in a particular season in a more efficient manner. Such a device is necessary for every farmer and would increase the water efficiency to its best. Thus, groundwater issues will also be resolved, and water wastage will also be reduced. The use of diesel pumps will also be reduced, saving non-renewable resources

ACKNOWLEDGEMENT

We would like to thank Mr. Sachin Trankatwar, our guide who has helped us through this whole journey, our project coordinator Mr. S. D. Biradar for guiding and being with us throughout the project development, Dr. B. H. Patil, Head of Department, Electronics and Telecommunication Engineering and our honorable Principal Dr. R. S. Bichkar, VPKBIET, Baramati for motivation and their cooperation in completing our research on the topic ”Use Of Digital Technology For Micro Irrigation System To Improve Water Efficiency of Irrigation Sector”.

We would like to express our gratitude to all of our teachers for their help and guidance. We would not have been able to complete this project without their help and cooperation. And we are very thankful for this opportunity that we got.

REFERENCES

1. J. Doorenbos, W. Pruitt, Guidelines for predicting crop water requirements. FAO Irrigation and Drainage Paper 24, Food and Agriculture Organization, UN, Rome, 1977.
2. Brouwer, C., Heibloem, M., Irrigation Water Management. Training Manual, vol. 3. Prov. Ed., 60 pp. Rome, Italy: FAO, 1986.
3. G. Kavianand, V.M. Nivas, R. Kiruthika and S. Lalitha, “Smart drip irrigation system for sustainable agriculture”, 2016 IEEE Technological Innovations in ICT for Agriculture and Rural Development (TIAR), Chennai, 2016, pp. 19-22
4. D. Mishra, A. Khan, R. Tiwari and S. Upadhyay, “Automated Irrigation System-IOT Based Approach”, 2018 3rd International Conference On Internet of Things: Smart Innovation and Usage (IoT-SIU), Bhimtal, 2018, pp. 1-4.
5. R. Varghese and S. Sharma, "Affordable Smart Farming Using IoT and Machine Learning," 2018 Second International Conference on Intelligent Computing and Control Systems (ICICCS), Madurai, India, 2018, pp. 645-650.
6. Parihar, Yogendra Singh, (2019) Internet of Things and Nodemcu A Review of use of Nodemcu ESP8266 in IoT products. 6. 1085.
7. Agavanakis, Kyriakos & Karpetas, George & Taylor, Michael & Pappa, Evangelia & Michail, Christos & Filos, John & Trachana, Varvara & Kontopoulou, Lamprini, “Practical machine learning based on cloud computing resources,” AIP Conference Proceedings 2123, 020050 (2019).
8. Shilpa Chandra, Samiksha Bhilare, Mugdha Asgekar and Ramya R. B., “Crop Water Requirement Prediction in Automated Drip Irrigation System using ML and IoT ,” 2021 International Conference on Nascent Technologies in Engineering (ICNTE 2021)