Smart Plant Monitoring System: A Review

Prof. Sujata Dake[1], Sakshi Girhepunje[2] , Faneshwari Mate[3], Sweta Mate[4] , Komal Sonwane[5]

[1]Project Guide, Department of Computer Science & Engineering, Wainganga College of Engineering and Management, Nagpur, Maharashtra.
[2345]Students, Department of Computer Science & Engineering, Wainganga College of Engineering and Management, Nagpur, Maharashtra.

Abstract-

Plants are vital for conserving the ecological cycle and maintaining the balance of the food chain. With rapid technological advancements, agriculture has been transformed significantly, reshaping how we approach farming practices. Today, people are accustomed to staying connected to the internet while performing daily activities like watching television or cooking. This connectivity has extended into agriculture, where the Internet of Things (IoT) and Artificial Intelligence (AI) have revolutionized farming. These technologies allow for real-time monitoring, automation, and data-driven decision-making, improving crop yields and resource management. IoT devices track soil moisture, weather conditions, and plant health, while AI helps optimize planting schedules, water usage, and pest control. Together, these innovations make farming more efficient and sustainable.

Keywords – IOT, Humidity, Moisture, Monitoring, Temperature etc.

1. Introduction

Plants have an important function in preserving the natural cycle and maintaining the food chain. They are essential for maintaining the balance of ecosystems, as they serve as the primary producers that form the base of the food pyramid. Plants help maintain soil health, regulate the climate by absorbing carbon dioxide, and provide oxygen, all while serving as the source of food and shelter for various species, including humans. As the global population grows, so does the demand for food, making agriculture one of the most important sectors for sustaining human life. However, the rapid advancement of technology is transforming the way people live and interact with the world, and agriculture is no exception. In recent years, technology has redefined farming practices and has brought innovations that have increased productivity, efficiency, and sustainability.

In today's world, people are increasingly connected to the internet, integrating it into their daily routines, from watching television to cooking meals. This constant connectivity has paved the way for technological advancements to enter new sectors, including agriculture. Technologies like the Internet of Things (IoT) and Artificial Intelligence (AI) have emerged as game-changers in farming, leading to smarter, more efficient agricultural practices. These advancements hold the potential to address some of the most pressing issues in the sector, such as food shortages, inefficient farming methods, and environmental degradation.

In many developing countries, particularly in regions like Asia and Southeast Asia, food shortages remain a significant problem. Despite advancements in technology, millions of people still face hunger, with approximately 10 million people dying each year due to insufficient food supply. Much of this is attributed to outdated farming techniques and the reluctance of farmers to adopt newer technologies. Traditional farming methods are often inefficient, leading to reduced crop yields and increased vulnerability to environmental factors like droughts and floods. In contrast, modern technology, including IoT and AI, offers solutions that can help address these challenges, improving both the quantity and quality of food production.

IoT technology, in particular, has revolutionized farming by facilitating real-time monitoring and automation. The concept behind IoT is to establish communication between devices through the internet, creating a vast network of interconnected systems that

can collect, share, and analyze data. IoT devices are equipped with sensors that gather information about various environmental conditions, such as soil moisture, temperature, humidity, and light intensity. This data is transmitted to cloud servers where it can be accessed and analyzed in real time, allowing farmers to make informed decisions about planting, irrigation, and pest control. With the help of IoT-based systems, farmers can monitor their fields remotely and ensure that crops are receiving the proper care, even from afar.

In developed countries, the adoption of IoT and AI in agriculture has already demonstrated its benefits in terms of efficiency and sustainability. However, in many developing nations, the majority of farmers still rely on traditional methods. The lack of awareness and accessibility to modern technology limits food production, which contributes to widespread hunger and malnutrition. To address this issue, IoT and AI-based solutions are being proposed as a means of bridging the gap between traditional farming and modern technology. By introducing IoT-powered plant monitoring systems, farmers in these regions can increase productivity and meet the growing demand for food.

One such IoT-based solution involves real-time plant monitoring, where sensors are deployed to measure key environmental parameters such as temperature, humidity, and light intensity. These sensors are placed in the field or garden to monitor the health of the plants and ensure they are receiving the necessary conditions for optimal growth. The collected data is stored in the cloud, where it can be accessed through smartphones or other connected devices. This enables farmers to monitor their crops from anywhere and at any time, providing them with the flexibility to manage their farms more efficiently. Additionally, by using this data, farmers can identify patterns and make predictions about the future conditions of their crops, allowing them to take proactive measures to prevent damage or loss.

The integration of AI into agriculture further enhances the capabilities of IoT systems. AI algorithms may evaluate data received from internet of things gadgets and deliver actionable insights for farmers. One important application of AI in agriculture is in disease detection and classification. By analyzing the color features, shape, and texture of plant leaves, AI models can identify diseases early and recommend appropriate treatment measures. This is particularly important in regions where access to agricultural experts is limited, as AI can serve as a virtual assistant, guiding farmers in managing their crops more effectively.

In addition to disease detection, AI can also help optimize farming practices by analyzing weather patterns, soil conditions, and crop growth stages. AI models can predict the best times for planting, watering, and harvesting crops, ensuring that farmers can make the most efficient use of their resources. This not only improves crop yields but also reduces waste and environmental impact by minimizing the use of water, fertilizers, and pesticides.

The use of IoT and AI technologies in agriculture has the potential to revolutionize the way food is produced, particularly in developing countries where food shortages are a persistent problem. By enabling real-time monitoring, automation, and data-driven decision-making, these technologies can help farmers increase productivity, reduce waste, and improve the overall sustainability of farming practices. The introduction of IoT and AI-based plant monitoring systems can provide a much-needed solution to food insecurity, ensuring that the world's growing population has access to the food it needs.

2. Problem Statements

- The main problem in traditional farming is the inefficiency and limitations of outdated methods, which are unable to meet the growing demand for food in the face of population growth and climate change.
- Farmers often lack the tools to monitor real-time environmental conditions like temperature, humidity, and soil moisture, leading to poor crop yields and inefficient use of resources such as water and fertilizers.
- Additionally, the identification of plant diseases is often delayed, causing significant damage before corrective measures are taken. These issues are particularly prevalent in developing countries, where farmers rely heavily on traditional practices, resulting in food shortages and high rates of malnutrition.
- The lack of timely information and data-driven insights leaves farmers vulnerable to unexpected

weather changes, pests, and diseases, further exacerbating food production challenges.
- There is an urgent need for innovative solutions, like IoT and AI-based systems, to improve agricultural productivity and sustainability.

3. Literature Review

In India, 35 percent of the agricultural area was properly irrigated. And the monsoon provides water to about two thirds of the area. The use of irrigation increases agricultural output, decreases reliance on the monsoon, increases food security, and creates more employment opportunities in rural regions. Farmers are having issues with their irrigation system, namely how much water has to be supplied and when. Crop damage and water waste can occasionally result from overwatering. So, we must keep an approximate water level in the soil to prevent such harm.

C. Verdouw et. al. 2019, In this study, plant roots are equipped with humidity, wetness, and temperature sensors. A gateway unit (ESP8266) manages sensor data and transmits it to an Android application. This application was created to estimate the values of temperature, humidity, and moisture sensors that were programmed into a microcontroller to regulate the amount of water.

M. A. Zamora-Izquierdo, et. al. 2019, A review article According to an IoT-based plant monitoring system[2], 35% of the land in India has reliable irrigation. Moreover, the monsoon provides water to around two thirds of the land. The use of irrigation increases agricultural output, decreases reliance on the monsoon, increases food security, and creates more employment opportunities in rural regions. Farmers are having issues with their irrigation system, namely how much water has to be supplied and when. Crop damage and water waste can occasionally result from overwatering. So, we must keep an approximate water level in the soil to prevent such harm.

N. Ahmed, et. al. 2018, A review article Prototyping is the initial phase in creating an Internet of Things (IoT) product, according to Internet of Things and Node MCU[3]. An IoT prototype consists of a user interface, hardware components including sensors, actuators, etc CPUs, backend programs, and connections. Prototyping is done using an IoT microcontroller unit (MCU) or development board. Low-power CPUs used in IoT microcontroller units (MCUs) or development boards allow for numerous programming environments, the firmware-based collection of data from sensors, and the transmission of raw or processed data to a local or cloud-based server. NodeMCU is an open-source firmware that supports the ESP8266 wifi chip, based on the LUA language for programming.

Bhuvan Puri, et. al. 2020, Because they absorb carbon dioxide and release oxygen into the atmosphere, plants serve a crucial role in maintaining a healthy ecosystem. Nonetheless, it is necessary to give the needed monitoring and to preserve the right plant growth and health. An artificial intelligence (AI) and internet of things (IoT) based solution is suggested to monitor the plant's growth and health in order to allay these worries. This study demonstrates how environmental sensors, such as DHT 11 and soil moisture meters, can monitor plants in real time. The machine learning models were used to real-time variables saved on a cloud server to forecast the growth of the plant. The system's output is examined using statistical measures such the RMSE and MAE.

Prathamesh Pawar , et. al. 2022, This essay examines the use of IOT in daily life for various applications and provides a quick primer on the technology. IOT makes a substantial contribution to cutting-edge farming techniques. So, we are attempting to show IOT with an automatic watering system. The soil's approximate moisture level is monitored and kept constant by a computerized watering system. The control unit uses an Arduino UNO for a microcontroller. The system makes use of sensors to measure the approximate temperature, moisture content, and humidity of the soil: temperature, moisture, and humidity. This value enables the system to use the proper amount of water, preventing excessive or insufficient irrigation.

We have examined numerous earlier studies conducted in this area by various researchers. Using technology in agriculture is crucial for both improving output and minimising labour requirements.

4. Research Methodology

Block Diagram:

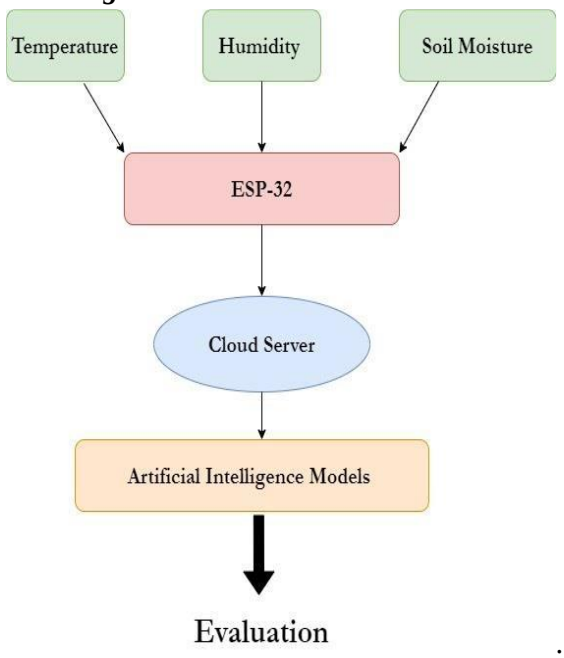

Figure 1: Block diagram of system

Working:

A. Sensors: In this project, two different sensors are used to monitor three environmental parameters such as atmospheric temperature, humidity and soil moisture. The sensors are discussed as follow:

a. DHT11: The DHT11 is a combined temperature and humidity sensor. The sensor is equipped with the dedicated negative temperature coefficient for the temperature measuring. This sensor is pre-calibrated from the manufacturer and ready to interface with any processing unit. It is enough to measure the temperature and humidity from 00 C to 500C and 20% to 90% respectively.

b. Soil Moisture Sensor: Soil moisture is used to measure the moisture present in the soil. This sensor has two metallic pad works as a probe for the sensor as well as acts as a variable resistor. These two long pads conduct a percentage of the water inside the soil. More water means more conductivity between the pads, less resistivity and higher voltage is out from the sensor.

B. Processing Unit: The processing unit is the major component in any kind of IoT system. It is used to fetch the data from the sensors, then process into valuable and readable form and lastly it helps to transfer into cloud or other devices via Bluetooth or Wi-Fi communication. In this project, ESP32 is the main processing unit that helps to capture the sensor's data, then processed and sent to Thingspeak cloud.

C. IoT Cloud Server: ThingSpeak is an open source IoT platform that provides their API to send, store and fetch data through the protocol. The main services provided by the ThingSpeak platform are multi sensor data logging, providing GPS coordinates and social network of things.

D. Artificial Intelligence Models: There are AI models used in this project.

Evaluation Parameters: In this project, performance evaluation of the models is performed using statistical methods.

5. Advantages

- The system is inexpensive in terms of hardware components and power consumption.
- The system helps in saving of water and electricity. It can be applied in large agricultural areas.
- The system helps the labour problem when there are no workers to work with and eliminate manpower.
- The system may be switched into manual mode if necessary.
- It is convenient to all climatic conditions and all sorts of irrigation.
- Monitoring the levels of water source from remote places.

6. Applications

Irrigation can be completed on farms, orchards, farms etc. It is effective for a variety of crops. This application is useful for monitoring the patient. Software applications developed for this system can be used for domestic tasks such as tank storage. The system is operated automatically and manually.

- IoT Irrigation Control.
- Soil Nutrient Analysis.
- Smart Greenhouses.
- Precision Farming.
- Data Analytics.

7. Conclusion

The development of a Smart Garden network utilizing the Internet of Everything has been proven to work satisfactorily by linking several soil characteristics to the cloud and effectively controlling it remotely via a mobile application. The system intended not only monitors sensor data, such as moisture, humidity, temperature, and ultrasonic, but also actuates additional variables according to the requirement. For instance, when the water level in the tank drops to a minimum value, the motor switch is automatically turned on until the water level of the tank attains the maximum value.

This system's initial cost and installation are low, therefore it may be deployed almost anyplace. The system can be advanced towards the next level as sensor technology advances, allowing customers to make the most of their investment. If soil nutrient monitors can be attached, the system can be changed to deliver fertilizers to the plants with precision. This technique saves manpower while efficiently utilizing available water resources, resulting in increased profit. The system's comments will improve how the gardening procedure is implemented.

A system for monitoring soil temperature, humidity, and moisture level was built, and the project allows for the assessment of existing systems, as well as their benefits and downsides. Agriculture is among the most water-intensive activities. The proposed system can be utilized to turn the motor (on/off) based on favorable plant conditions, i.e. sensor values, thereby automation the watering operation. This is one among the most time-efficient farming chores, preventing soil over- or under-irrigation and thereby minimizing crop damage. The proprietor of the farm can watch the procedure online using an Android app. Though this project might conclude that there can be great improvement in agriculture with the usage of IOT and automation.

Plants are crucial to our daily lives and help to preserve our eco-friendly lifestyle. It is necessary to maintain their appropriate growth and an adequate supply of water for a healthy life. This project develops an intelligent plant tracking system using internet of things and artificial intelligence technology. Three critical factors, including atmospheric temperature, humidity, & soil moisture, are measured in real time and transmitted to a cloud server for further analysis. The study used two distinct statistical models: ANN and SVM. To analyze the models created by machine learning, two statistical metrics are utilized, among them RMSE and MAE.

8. Future Scope

The performance of the system can be further improved in terms of the operating speed, memory capacity, and instruction cycle period of the microcontroller by using other high end controllers. The number of channels can be increased to interface more number of sensors which is possible by using advanced versions of controllers.

The system can be modified with the use of a data logger and a graphical LCD panel showing the measured sensor data over a period of time. A speaking voice alarm could be used. The device can be made to perform better by providing the power supply with the help of renewable source. Time bound administration of fertilizers, insecticides and pesticides can be introduced.

1. To Add Security to Device and Owner’s Account.
2. Detect amount of Sunlight available for plant.
3. To Implement AI and Check whether plant is in good condition or not.
4. Making Product compact so that can be fitted anywhere.
5. Can use solar cell to charge battery so need of Plug.

Acknowledgment

I would like to use this opportunity to show our sincere appreciation and respect to our project guide at the Wainganga Collage of Engineering and Management, Nagpur, who gave us direction and space to complete this assignment.

References

[1] Bhuvan Puri, IoT and AI-based Plant Monitoring System, Vol. 04, No. 3 ,(2020), (135-142), International Journal of Machine Learning and Networked Collaborative Engineering, D.A.V. Institute of Engineering and Technology, Jalandhar, Punjab

[2] Dr. Senthil Kumar M, Sneha K, Chidhambararajan B, RajaKumar M , IoT and AI-based Plant Monitoring System, , Gorteria Journal, 2020, Pp: 185-190

[3] Dr. Hetal Patel, Dr. Shailesh Khant, Dr. Atul Patel, Artificial Intelligence and IoT based Smart Irrigation system for Precision Farming, CHARUSAT, Changa, India Vol.12 No.10 (2021), 4462-4467

[4] Athawale, S. V., Solanki, M., Sapkal, A., Gawande, A., & Chaudhari, S. (2020). An IoT-Based Smart Plant Monitoring System. In Smart Computing Paradigms: New Progresses and Challenges (pp. 303-310). Springer, Singapore.

[5] Singh, R., Srivastava, S., & Mishra, R. (2020, February). AI and IoT Based Monitoring System for Increasing the Yield in Crop Production. In 2020 International Conference on Electrical and Electronics Engineering (ICE3) (pp. 301-305).IEEE.

[6] Kohli, A., Kohli, R., Singh, B., & Singh, J. (2020). Smart plant monitoring system using IoT technology. In Handbook of Research on the Internet of Things Applications in Robotics and Automation (pp. 318-366). IGI Global.

[7] Bin Sadli, M. D. D. (2019, April). An IoT-based Smart Garden with Weather Station System. In 2019 IEEE 9th Symposium on Computer Applications & Industrial Electronics (ISCAIE) (pp. 38-43). IEEE.

[8] Puri, V., Chandramouli, M., Van Le, C., & Hoa, T. H. (2020, March). Internet of Things and Fuzzy logic based hybrid approach for the Prediction of Smart Farming System. In 2020 International Conference on Computer Science, Engineering and Applications (ICCSEA) (pp. 1-5). IEEE.

[9] Siddagangaiah, S. (2016). A novel approach to IoT-based plant health monitoring system. Int. Res. J. Eng. Technol, 3(11), 880-886.

[10] Tangworakitthaworn, P., Tengchaisri, V., Rungsuptaweekoon, K., & Samakit, T. (2018, July). A game-based learning system for plant monitoring based on IoT technology. In 2018 15th International Joint Conference on Computer Science and Software Engineering (JCSSE) (pp. 1-5). IEEE.

[11] Ezhilazhahi, A. M., & Bhuvaneswari, P. T. V. (2017, May). IoT enabled plant soil moisture monitoring using wireless sensor networks. In 2017 Third International Conference on Sensing, Signal Processing and Security (ICSSS) (pp. 345-349). IEEE.

[12] Pavel, M. I., Kamruzzaman, S. M., Hasan, S. S., & Sabuj, S. R. (2019, February). An IoT based plant health monitoring system implementing image processing. In 2019 IEEE 4th International Conference on Computer and Communication Systems (ICCCS) (pp. 299-303). IEEE.

[13] Athawale, S. V., Solanki, M., Sapkal, A., Gawande, A., & Chaudhari, S. (2020). An IoT-Based Smart Plant Monitoring System. In Smart Computing Paradigms: New Progresses and Challenges (pp. 303-310). Springer, Singapore.

[14] Singh, R., Srivastava, S., & Mishra, R. (2020, February). AI and IoT Based Monitoring System for Increasing the Yield in Crop Production. In 2020 International Conference on Electrical and Electronics Engineering (ICE3) (pp. 301-305). IEEE.

[15] Ragavi, B., Pavithra, L., Sandhiyadevi, P., Mohanapriya, G. K., & Harikirubha, S. (2020, March). Smart Agriculture with AI Sensor by Using Agrobot. In 2020 Fourth International Conference on Computing Methodologies and Communication (ICCMC) (pp. 1-4). IEEE.

[16] Bhanu, K. N., Jasmine, H. J., & Mahadevaswamy, H. S. (2020, June). Machine learning Implementation in IoT based Intelligent System for Agriculture. In 2020 International Conference for Emerging Technology (INCET) (pp. 1-5). IEEE.

[17] Walczak, S. (2019). Artificial neural networks. In Advanced Methodologies and Technologies in Artificial Intelligence, Computer Simulation, and

Human-Computer Interaction (pp. 40-53). IGI Global.

[18] Quek, S. G., Selvachandran, G., Munir, M., Mahmood, T., Ullah, K., Son, L. H., ... & Priyadarshini, I. (2019). Multi-attribute multi-perception decision-making based on generalized T-spherical fuzzy weighted aggregation operators on neutrosophic sets. Mathematics, 7(9), 780.

[19] Gholami, R., & Fakhari, N. (2017). Support vector machine: principles, parameters, and applications. In Handbook of Neural Computation (pp. 515-535). Academic Press.

[20] Martínez-Ramón, M., & Christodoulou, C. (2005). Support vector machines for antenna array processing and electromagnetics. Synthesis Lectures on Computational Electromagnetics, 1(1), 1-120.

[21] Kecman, V., & Wang, L. (2005). Support vector machines: theory and applications.

[22] Tuan, T. A., Long, H. V., Kumar, R., Priyadarshini, I., & Son, N. T. K. (2019). Performance evaluation of Botnet DDoS attack detection using machine learning. Evolutionary Intelligence, 1-12.

[23] Gay, W. (2018). DHT11 sensor. In Advanced Raspberry Pi (pp. 399-418). Apress, Berkeley, CA.

[24] Singh, P., & Saikia, S. (2016, December). Arduino-based smart irrigation using water flow sensor, soil moisture sensor, temperature sensor and ESP8266 WiFi module. In 2016 IEEE Region 10 Humanitarian Technology Conference (R10-HTC) (pp. 1-4). IEEE.

[25] Maureira, M. A. G., Oldenhof, D., & Teernstra, L. (2011). ThingSpeak–an API and Web Service for the Internet of Things. World Wide Web.