IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

ARTIFICIAL INTELLIGENCE INTEGRATED SMART IRRIGATION SYSTEM

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Abstract: One of the oldest and most important industries is agriculture. The demand for work and food is rising due to the world's population growth. Because traditional farming methods are insufficient, new automated ways of achieving food requirements are being developed. In several regions of the nation, the growing demand for water has raised serious questions regarding the viability of irrigated agriculture. Therefore, one of the most important practical concerns for increasing the effectiveness of water utilization in irrigation systems is determining crop water demand. Some areas of a field receive unneeded irrigation from the current sensor-based systems, leaving other areas without any irrigation at all.

Artificial intelligence (AI) has been employed extensively in farming recently. AI technology is being used in agriculture to improve soil and growth conditions, produce healthier crops, evaluate data for farmers, and perform various jobs related to food supply chain management. AI-powered technologies will help farmers increase crop quality and yield more with less resources. Farmers can obtain information on the health of their crops, including the amount of water and nutrients needed to boost yield quality and quantity, by using an AI-powered health monitoring system

***Index Terms*- Artificial Intelligence, Sensor, Irrigation.**

I. INTRODUCTION

An important part of the Indian economy is the agricultural sector. In nations such as India, the agricultural industry employs half of the labour force and contributes 18% of the GDP. [8]Growth in the agricultural sector will hasten rural growth, which will drive rural transformation, which will finally result in structural change. Since the development of technology, many industries have undergone considerable transformations globally. Despite being the least digitalized business, agriculture has surprisingly seen a surge in the development and commercialization of agricultural technologies. Artificial intelligence (AI) is a novel technique in agriculture. Today's agriculture system is at a new level because to artificial intelligence (AI)-based equipment and technologies. Investigating how humans learn, think, make decisions, and collaborate to solve issues is the basis for developing intelligent software and systems. This technology has its roots in this research. By providing them training data, these intelligent devices—much like the human brain—give us the intended outcome for every valid input. The main objective of AI is to simplify problem solving, which may entail the use of artificial neural networks (ANN). Astonishing self-organization and versatile learning capabilities are had by neural systems. Various disciplines, counting computer science, science, material science, building, picture and flag handling, financial matters and fund, reasoning, etymology, and neurology, have seen the substitution of numerous conventional strategies with it. Learning happens inside an artificial neural network (ANN). When the environment changes, learning is the method of altering to the alter in oneself. Since it can alter our environment and grow our recognitions, counterfeit insights artificial intelligence (AI) is beginning to gotten to be increasingly coordinates into our day by day lives. With these rising advances the workforces who were limited to as it were negligible mechanical divisions are presently contributing to various divisions.

II. DISCUSSION PER TOPIC

2.1Internet of Things (IOT)

The Internet of Things (IOT), a cutting-edge technology, is becoming increasingly important. Using a wireless sensor network, the Web server received the data gathered from the sensors. The sensed data is processed and analyzed by (IOT) framework. [6] The solutions built on (IOT) are proving. Extremely beneficial in a variety of ways for the agricultural environment. (IOT) technology is very useful for agricultural systems because it makes physical components like plants, pots, irrigation valves, and moisture sensors, among others, into online objects on the Internet that are represented by tags or unique identifiers. Such components can thus be observed or managed via the Internet, permitting the cultivation of a crop from a distance and simplifying operations that normally need for the worker's physical presence. [6] Farmers can now have even more access to information on the precise state of their field, including soil moisture, humidity, soil temperature, water requirements, weather conditions, and much more, thanks to technology like sensors and (IOT). All gadgets that are connected to the internet and have ability to communicate with other electronic equipment can be considered as part of (IOT).[5]

2.2Machine Learning (ML)

ML makes use of these data by feeding mathematical algorithms with them in an effort to forecast or categorize a certain variable of interest. The crop's necessary irrigation times can be estimated, for instance, using the evapotranspiration value. There is a wide range of machine learning algorithms, and they are divided into several subfields based on their complexity and intended use. The papers that were analyzed contain examples of how they are used in irrigation systems. For example, suggests a system. A feed-forward neural network algorithm (a bioinspired ranking algorithm) is also used in this system, and gradient descent and variable learning rate gradient descent two algorithms that solve optimization problems through first-order iterations are used to optimize the training of the neural network. [6, 3]

2.3 Artificial Intelligence (AI)

To fulfill the increasing demand of food the agricultural industries need to adapt the latest advancements in agriculture such as use of Artificial Intelligence (AI) based techniques. Artificial Intelligence (AI) is offering innovative solutions to address the challenges with traditional irrigation methods and unsustainable practices. Smart irrigation system driven by Artificial Intelligence (AI) algorithms is revolutionizing the way uses of water in agriculture. Artificial Intelligence (AI) has become extensively employed, enabling precise monitoring and analysis of related various factors. Artificial Intelligence (AI) based techniques with inclusion of image processing, deep learning provides an easy and effective way for crop health monitoring. Artificial Intelligence (AI) technology monitor the field, monitor requirement of crop using the real time data and control the wastage of water, pesticides, etc. [9,4]

III. Understanding smart irrigation system

An innovative method for automating irrigation systems and reducing water consumption is the SMART irrigation system, which improves performance. This method allows farmers to meet their need using a newly accepted strategy that conserves water for the irrigation process since it modifies irrigation depending on actual soil and weather conditions. Data processing, wireless connection, fault detection, irrigation control, and data collecting (sensor) are all included in the SMART irrigation system. These parts are all compatible with Internet of Things devices. [5] Smart irrigation systems that use less water and can irrigate a larger area. A thorough analysis of numerous smart irrigation strategies is provided. Nonetheless, there are a number of low-water-consumption irrigation solutions available, such as drip and sprinkler systems; nonetheless, these systems mostly rely on human interaction. It is possible to create smart irrigation systems by adding features to currently operating systems. The device continuously checks the amount of water in a crop, comparing the amount of water in the soil and crop plants to the amount of water that is typically needed. Various types of sensor data collected as shown in fig 1.

3.1 Soil Moisture Sensors

Soil moisture sensors are used to measure the amount of water in the soil. They are useful instruments for research, environmental monitoring, gardening, and agriculture. With the use of these sensors, farmers can better regulate their irrigation system, use less water, and increase crop productivity.

3.2 Temperature Sensors

In sensor-based irrigation system, temperature in the field, help in monitoring environmental conditions, optimizing irrigation schedules, and preventing water waste. By incorporating temperature-based insights into irrigation strategies, farmers can enhance productivity, conserve water, and mitigate the impacts of environmental stressors on crops.

3.3 Humidity Sensors

In irrigation systems, humidity sensors are useful parts that provide vital information for maximizing water management strategies and guaranteeing productive crop growth. The amount of atmospheric moisture surrounding the plants is determined by humidity sensors, which monitor the moisture content in the air. Irrigation systems that regularly measure humidity levels are able to evaluate the environments overall moisture balance and modify watering schedules accordingly. Low humidity levels may suggest more water loss from soil and plants, while high humidity levels may indicate decreased rates of evapotranspiration.

3.4 Rainfall Sensors

Rainfall Sensors measure the amount of precipitation that falls onto the soil surface. They detect both the presence and intensity of rainfall events, providing accurate data on rainfall volume over specific time intervals. This information is essential for determining whether irrigation is necessary and, if so, how much water needs to be applied. Irrigation is only applied when rainfall is insufficient to meet crop water requirements, minimizing water waste and promoting sustainable water use practices.

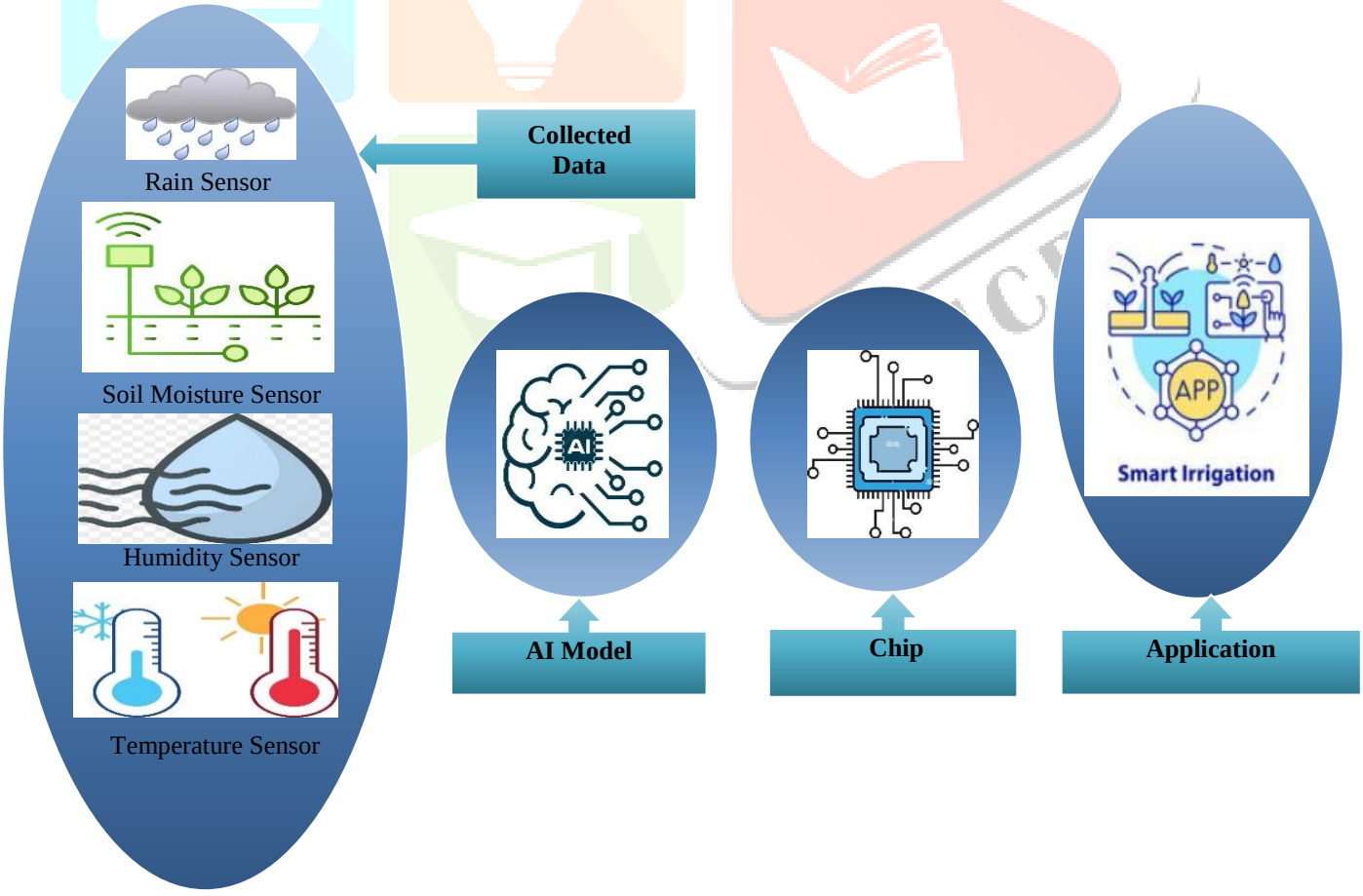

Figure 1. Artificial Intelligence (AI) Model Working Process.

IV KEY COMPONENTS AND CONCEPTS OF ARTIFICIAL INTELLIGENCE (AI) INTEGRATED SMART IRRIGATION SYSTEM

4.1 Sensors and Data Collection

Collect and store real-time data and historical data for analysis and decision making. Enable communication between sensors, controllers, and other components for real- time data exchange. Provide farmers with access to sensor data and irrigation controls through web-based interfaces or mobiles applications.

4.2Artificial Intelligence (AI) Algorithms

Machine Learning: Analyze historical data to create predicting models for water demand, crop growth, and irrigation scheduling. Neural Networks: Using you may train models to identify trends in sensor data and make the best irrigation decisions based on leaned patterns. Reinforcement Learning: Enable irrigation systems learn from errors and adjust over time to become more efficient. Regression Analysis: AI systems use data on temperature, humidity, solar radiation, soil type, and crop type to determine how much water crops require. This information is then used to schedule irrigation precisely

4.3 Optimization Algorithms

Genetic Algorithms: By generating and evaluating a number of possible solutions depending on variables including crop stages, water availability, and environmental conditions. Artificial Intelligence (AI) algorithms simulate the collective behavior of swarms to find optimal irrigation strategies that balance water usage, crop yield, and maximize resource efficiency. Through trial and error, Artificial Intelligence (AI) agents discover the best irrigation strategies and they are rewarding or penalized according to how well their irrigation decisions outcomes.

4.4Automation and Control

One of the significant advantages of smart irrigation systems is their ability to deliver water with precision. Rather than uniformly applying water to an entire field. These systems can target specific areas based on their unique water requirements. This targeted approach minimizes water wastage, reduces runoff and prevents overwatering. This will ensure that crops receive optimal moisture levels for healthy growth. [9]

4.5 User Interface and Visualization

Provide farmers with easy to use monitoring and decision-making tools by displaying real-time status information. Alert farmers to important events so they may take appropriate action such as low soil moisture levels or equipment failure.

Figure 2. Flow Chart

V. CHALLENGES

- Data quality and availability
- Model complexity and calibration
- Interdisciplinary integration
- Cost and Affordability
- Energy and Connectivity

VI. CONCLUSION

AI-integrated smart irrigation system represents a powerful tool for modern agriculture, offering a holistic approach to water management, crop production, and resource conservation. By harnessing the capabilities of artificial intelligence, sensor technologies, and decision support systems, farmers can achieve sustainable and profitable agriculture while mitigating the challenges posed by climate change, water scarcity, and environmental degradation. This project paper underscores the importance of continued research, innovation, and adoption of technology-driven solutions to address the evolving needs of the agricultural sector and ensure food security for future generations.

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