Smart Irrigation Management System Using Machine Learning and Wireless Sensor Network

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The art of raising cattle and crops spontaneously from the earth is another name for it. Agriculture contributes to the nation's economic system by giving the population access to food and raw resources as well as job possibilities. But as the population grows and food demand rises, farmers will need more water to irrigate their fields. Water needs and physiological processes in plants are seasonal, vary from one season to the next, and are impacted by external elements like weather, humidity, solar radiation, etc. Precision irrigation systems are required because of the changing environmental circumstances. Due to little rainfall, freshwater is necessary for irrigation and the supply of nutrients for plant growth. 70% of the freshwater on the planet is used for agriculture.

Keywords: Agriculture yield, Irrigation System, Cluster Node, Wireless Sensor Network, Machine Learning Algorithm, RNN.

Introduction

The Latin words "Ager" and "Cultura" are the origin of the word "agricultural." Ager and Cultura both mean "land" or "field," therefore the word "agriculture" refers to the cultivation of land. The science of raising crops and cattle for economic and dietary needs is known as agriculture.

Due to the rising population and the need to produce food, the agricultural industry uses over 85% of the freshwater on Earth. Low food output and inefficient water utilization are two characteristics of the ancient irrigation technique. Changes in climate and global warming have an impact on how much rain falls, which is necessary to provide plants with the water they needed.

Precision irrigation is a crucial step in meeting food demand and a water-resource-saving strategy to offset the unpredictability of rainfall and the impact of water scarcity brought on by the current drought in many parts of the world. Precision irrigation ensures effective water utilization for each plant, when and where it is needed, in adequate amounts, to combat water loss through evapotranspiration, erosion, or deep percolation, and to prevent either over- or under-irrigation. In addition to saving water through monitoring and effective control, proper irrigation management also allows for a reduction in other elements, such as the use of fossil fuels or power to pump irrigation water.

The demand for presenting eco-friendly agricultural parameters such as soil moisture content, soil temperature measurement, air temperature, air pressure, wind speed, pH, salt content, groundwater, and plant water requirements is currently present. All these variables affect the farmer's requirements for the best field irrigation when necessary. A significant part of how many nations' economies are built nowadays is through agriculture. As a result of excessive fertilization in agriculture, farmland pollution, soil pH value, environmental deterioration, loss of biodiversity, salinity, and groundwater pollution have all occurred. These elements primarily have an impact on producing, growing, and developing agricultural products. The management of agricultural production is crucial to the long-term sustainability of contemporary agriculture.

Precision agriculture is necessary because of the unpredictable nature of rainfall, global warming, and population growth, which raise demand for water and other natural resources. A larger crop production is possible with modern agriculture, which may also be managed remotely at the farmer's convenience.

The farmer can also keep an eye on the farm if it is located far from him. Agriculture needs sophisticated systems to utilize water resources efficiently, and for this we need to implement wireless sensor networks that can monitor, control irrigation, and offer weather information. They aid in keeping the soil moist, which promotes healthy crop yields. By combining artificial intelligence and machine learning with the collection of real-time field data to improve the irrigation system and provide the farmer with the appropriate information regarding the best time for irrigation, advanced automated systems can increase the sustainability and efficiency of irrigation in agriculture. With the help of that automated technology, farmers can better understand their fields while spending less on irrigation and maintenance.

Drip irrigation, ditch irrigation, sprinkler systems, and terraced irrigation are the conventional methods of irrigation. The standard irrigation is categorised by a rise in productivity demand, a water shortage, and subpar agricultural output.

Automatic Irrigation is Required:

(i) Conserving energy and resources for careful use.

(ii) Simple system installation in the field.

(iii) To apply the appropriate quantity of water at the appropriate time to make it easier for farmers to manage farm irrigation and nurseries.

In automated irrigation systems, a switch gear is used to turn the on and off the motor.

(v) A sensor-based controller makes it simple to operate a pump or motor, eliminating the need for manual labour to keep an eye on irrigation systems.

Crop efficiency includes reducing overwatering from saturated soil and avoiding irrigation at the wrong time to conserve more water.

Due to the lack of affordable irrigation systems, a considerable portion of freshwater is used in agriculture. In climatology and geography, rainfall and evapotranspiration play a significant role in determining the soil's moisture content. The ratio of monthly (or annual) evaporation to precipitation is used to calculate the soil's wetness. The daily weather reports' ratio of daily evaporation to precipitation can also be used to compute soil moisture. Precipitation is directly accessible, whereas evaporation is derived from other metrological data.

Wireless sensor networks (WSNs) are a tool to support economic growth in the agricultural sector. The use of intelligent network technology in agriculture could increase output. Energy efficiency is one of the major problems with WSN. Sensor nodes are effectively used in agricultural productivity and water distribution by a water pipeline system. A water pipeline is a crucial piece of equipment for moving water across agricultural area for irrigation or human consumption. Leaks are a common issue with water pipeline transportation. As a result, water resources could be wasted, and pipes need to be monitored in real-time to stop water leaks. A wireless sensor network is a practical option for tracking water pipeline leaks in real time.

LITERATURE SURVEY

Many researchers doing research in order to develop new techniques for water conservation. The effects of five water harvesting techniques were studied in this study on different seasons for sessional analysis based on the dry and wet seasons. Their approach considered the soil's moisture content in three seasons—sowing, mid-season, and after harvest—at four different depths, and they discovered that it is useful for cutting water use and boosting productivity[1].

This method is for effective plant soil temperature maintenance, and the algorithm was coded in a microcontroller. It was powered by solar cells and communicated via a cellular internet interface. It is clear that the proposed irrigation method reduced water consumption by up to 90%[2].

Using the distributed clustering method, this method explains the efficiency and delay of the information-gathering mechanism. This technique helps provide a secure data delivery system to a BS, reducing data packet loss, and this method generates the minimum value is based on the transmission distance. The drip irrigation method helps to reduce crop water usage[3].

This is an efficient irrigation method that is used for both surface and large-scale processes. They were carried out in all seasons, including winter, autumn, spring, and summer. The main advantage of this method is that it uses less energy[4].

Using the temperature on the surface, this method is used to conduct a study on soil moisture. They chose features from the collected data using the probability distribution. Based on statistical analysis, their method is useful for maintaining soil moisture[5].

This approach makes use of temperature and precipitation analysis. To analyse the temperature of the weather, they developed a simulation. They observed that temperature and environmental events have an impact on the soil's moisture[6].

This research created a soil hydrological method for analysing groundwater effects. They conducted their research by allowing water to exchange between the unsaturated zone and the groundwater. It was found that soil moisture analysis is more crucial for efficient water saving. [8].

This research looks at a liquid-level sensor transducer that employs Metal Oxide Semiconductor technology and a specific power supply range. To detect rainfall, the transducer transforms the liquid level into a pulse and measures the rate of the pulse liquid level [9].

This study described the usage of a wireless sensor network to regulate irrigation that used a smart watering system. This technique measured the amount of water content in the farm's soil using a remote soil moisture sensor[10].

The architecture for efficient water management using sensors for data collection was discussed in this study. Based on a sensor network, this method is useful in agriculture [10].

This study developed a wireless control system for drip irrigation that didn't require any human involvement. This strategy had the advantage of providing information on the weather[11].

In order to forecast and detect drought conditions, this study explores a water shortages surveillance system for wireless networks. This system analyses climate and soil conditions [11].

The issues in the water budget approach model applied to Ireland were explained in this study. The model used monthly values of climatic variables such rainfall, temp, and sunlight hours, as well as specifics on land use, in order to determine the water balance [14].

This work described three unique algorithms—Top Order Pattern, pre-Validated Top Order Pattern, and Series String Compare estimating plant root water using soil humidity sensor time series information. To accurately anticipate future water needs, the paper compares the algorithms to a deployed technique called (DHC)[15].

The authors of this study explained the conceptual and operational framework used for various water management purposes. Additionally, to evaluate obstacles and potential fixes for problems. To demonstrate issues and offer artificial intelligence-based solutions, they conducted case studies[16].

This study used data from the Almudevar Irrigation District in Spain to explain irrigation system issues. Four climate change scenarios were examined in order to provide appropriate crop rotation recommendations. This study described new techniques for increasing energy and water efficiency. It employs a modified water intake for a set period of time and proposes an energy-efficient water management solution[17].

This study explained irrigation performance and employed the Genil-Cabra Irrigation Scheme for effective irrigation management and monitoring. The automated irrigation algorithm is based on properties such as adoption, scheduled execution, and a few external parameter monitoring techniques.

This study described a new drip irrigation system that is used to improve the system's efficiency in terms that use agronomic crops that consume both irrigation and rainfall while raising seasonal demands and calculating the amount of rain that the crop uses during a given rainy season. At long last, they have proven that their approach is better than others[18].

The first suggested hierarchical routing protocol is LEACH, which is well-known and illustrative. (CHs) and regular nodes are the two categories into which all sensing in LEACH fall (ONs). An ON will forward the information it is monitoring to the relevant CH, who will combine it and send it to the (BS). LEACH performs better than conventional routing methods in terms of extending network lifetime. But because CHs are chosen at random, they are typically dispersed unevenly and communicate with the BS directly, which results in severe energy loss [19].

In PEGASIS, each node only has to send the data package to the neighbour that is physically closer to the BS than it is to the source node. For inter-cluster communication, the greedy method joins CHs together form a chain. The data packets are then forwarded to the BS by each chain leader closest to it. The chain structure saves energy by avoiding long-distance transmission. Meanwhile, there could be a large network latency as a result of the usage of multi-hop propagation. This protocol is not appropriate for time-sensitive applications as a result [20].

In terms of CHs selection, the hybrid, energy-efficient, distributed clustering approach (HEED) [17] is a far superior alternative to LEACH. The primary feature is residual energy, and nodes having higher residual energy are more likely to be CHs. Thus, the first node's demise may be substantially postponed and more homogeneous CHs could be produced. The other factor considered to select which cluster a node should join is the latency of intra-cluster communication [21].

METHODOLOGY.

The system starts by using sensors node to determine the state of the field, then it informs the energy base of its findings. The system will start or stop working depending on certain conditions based on these parameter values after comparing them to predetermined set standard values like how the minimum water level is 5 cm. The sprinklers will switch on automatically when the water level drops to this level. The sprinklers will shut off automatically when the water level reaches 10 cm. The 35-degree Celsius upper limit has been set. Sprinklers are turned on automatically when the temperature reaches 35 degrees Celsius, and they are turned off automatically when it drops below 25 degrees Celsius. There are additional requirements for delivering insecticides. There is a shield for our field of study in our research. It uses a cluster node. A gadget called a cluster node uses frequency mapping to calculate how far away something is. A cluster node uses a transducer to transmit and receive information that convey data about an object's vicinity. The cluster node will alert a buzzer and the field manager if any animal attempts to enter a certain region of the field.

SCOPE OF WORK

Our model aims to:

1) End poverty by utilising cutting-edge technology and natural resources: The WSN- controlled smart agricultural monitoring system's primary goal is to combine the use of WSN with cutting-edge wireless networking technology in order to enhance and implement a low-cost monitoring system. The sensors are also made to properly utilise natural resources to monitor changes in food production and enhance it. By increasing the use of technology in low-income areas and making better use of natural resources, this will help to achieve the objective of ending poverty.

2) Increase agricultural productivity and farmer income beginning at the lowest level: Our strategy intends to raise agricultural productivity and field yields while also increasing farmer income at the lowest level. We have made an effort to concentrate the model on utilising natural resources and creating a robust and intelligent irrigation system, which is something that small farmers normally cannot do due to a lack of resources (money and labour).

3) Crop yield assurance: The model is sustainable because it requires little upkeep and mostly uses natural resources. Our strategy strives to make small farms and the agricultural ecosystem more resilient to climate, drought, and moisture problems that have an impact on the quality of the land and food. Additionally, there is a lot of space for the model to develop with the gathering of statistical data, making the subsequent iterations more sustainable.

4) Increased productivity: Our model intends to contribute to the objective of increasing economic productivity by introducing new technologies, expanding the potential for technological advancement, and boosting creativity levels in smaller communities through the use of WSN.

CONCLUSION

The irrigation and crop protection processes used in smart agriculture make use of natural resources and environmental conditions. Additionally, it offers the potential to industrially spread this throughout a sizable network, making it adaptable to a variety of industrial operations. The WSN -based approach discussed in this study has the potential to improve technological capabilities for various wireless sensor network configurations as well as for intelligent farming practises.

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