SMART AGRICULTURE SYSTEM USING MACHINE LEARNING

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Abstract: The most significant and abecedarian assiduity in India is husbandry, which contemporaneously balances global food demands and inventories the raw accouterments demanded for numerous other businesses. Innovative husbandry ways are gradationally perfecting crop yields, crop profitability, and irrigation waste reduction. This model is an intelligent irrigation system that predicts crop water conditions using a machine learning algorithm. The three main variables determining the water quantum needed for any agrarian crop are moisture, temperature, and humidity content. With this system comprising temperature, moisture, and humidity detectors set in an agrarian field and transferring data through a microprocessor, an Internet of Effects device with pall functionality is being constructed. When applied to field data, the decision tree system is a machine learning (ML) fashion that seems to be efficient in soothsaying results. growers can arrange their water force ahead of time with the help of a correspondence alert that contains the decision tree algorithm's results.

Keywords: Decision Tree Algorithm, Alert to registered number, Soil Moisture, Temperature, Humidity, and Irrigation System.

I. INTRODUCTION

The Internet of Things is an innovative technological advancement that enables the global monitoring and control of devices, bridging the gap between living beings and machines. This transformative technology is revolutionizing various industries and is now accessible to everyday users. The IoT has introduced numerous methods to enhance human comfort and convenience, such as automation, smart cities, e-health, and advancements in education [4]. However, these advancements should also be directed towards essential needs like food production from agricultural areas, rather than solely focusing on human comforts.

With the projected population growth, the World Bank estimates that more than 50% of the world's food supply will need to be increased by 2050 in [1]. This task becomes challenging due to ongoing climate changes that affect large-scale agricultural production. To address this challenge, the use of hydroponic farming, drones, advanced tractors, and field-based sensors could enable future farmers to significantly enhance food production while minimizing costs. Consequently, the demand for advanced farming techniques is rapidly growing.

Notably, agriculture contributes significantly to water consumption, making it crucial for farming regions to engage in more conversations and implement effective measures to ensure sustainability [9]. Profitability remains a critical aspect of the agricultural industry's sustainability efforts.

India has a well-known reputation for producing high-quality agricultural products. It is crucial to take into account the water system requirements to enhance crop yields. To ensure the healthy growth of crops, it is essential to utilize the right irrigation methods at proper intervals [3]. The agricultural sector has the highest demand for workers, yet a decline in the workforce was mainly due to limited opportunities and young people's lack of interest in farming. Farmers who devoted their time to tending to crops in huge areas had to spend their entire time outdoors to ensure successful harvests [7]. While some farmers experienced great success, they also encountered significant setbacks due to unpredictable and challenging weather conditions.

The looming threat of a severe water shortage in the future has significantly influenced the content presented in this document. Agriculture is India's primary industry, with a substantial reliance on water for its fields. More than 80% of water resources are dedicated solely to agricultural activities. The current trajectory could lead to the complete depletion of water resources, prompting the suggestion of a model to regulate water usage [6]. The adoption of advanced technology in agriculture is vital to promote increased land productivity.

II. RELATED WORK

A proposed irrigation system strategy aims to reduce water wastage and automate the water system for large agricultural areas, as outlined by the authors in [1]. This system utilizes soil moisture, humidity, and air temperature to determine the water needed by the crops. Through a machine learning approach, the system compares observed sensor values with a set threshold sent to machine learning for further analysis. Subsequently, the machine learning system compares the obtained results with the prediction to decide on the water supply continuation. The user simply needs to tap once to activate the water supply upon receiving an instant notification on their smartphone. Additionally, a web application is available for the user to access detailed sensor data and evaluate changes in sensor readings over time. The system is adaptable to various plant types, providing a list of plant options through mobile and web applications [12].

This gives producers better control over the specific plant species they are growing, leading to more precise estimations of irrigation needs and threshold limits. If internet connectivity is not available, an SMS alert can be set up. By responding to the SMS, the user may decide whether to turn off or on the crop's water supply based on the estimates.

Described in [2] as the "gateway between things," IoT has been emphasized by the authors regarding the importance of watering outdoor crop areas and the necessity of robust agricultural systems, highlighting agriculture's significance to Thailand's economy. Kalman filtering techniques are employed to eliminate noisy data from sensor data for more accurate values. The system incorporates various physical parameters and soil moisture data obtained from sensors [10]. To determine the precise timing for initiating irrigation at a given standard, a decision tree model is utilized. Furthermore, a smartphone application is developed to enable farmers to monitor their areas periodically.

In [3], an IoT-based irrigation system aimed at reducing water waste in South Algerian regions is introduced. Constrained Application Protocol (CoAP), Wireless Sensor Networks, and Internet of Things were utilized to create an intelligent irrigation system crucial for monitoring and controlling water use more efficiently. This system is reported to be sophisticated, cost-effective, and most importantly, designed to control water supply via the Internet.

The authors of [4] describe an Android-powered smartphone that may be used to remotely control an automated watering system. When various soil compositions lead to a predefined threshold, a voltage signal is transmitted by a soil moisture sensor. This data is sent from a mobile device to a Raspberry Pi using the HC05 module. The findings are displayed and the irrigation system's on/off switch is controlled via the user interface, which may be accessed using a smartphone. This technique can be applied in real-time settings because of its adaptability.

Introducing IoT as a means to collect and provide users with physical data, the authors of [5] also address strategies for dealing with various issues, including identifying pests and different agricultural threats. Python scripts are utilized in developing Internet of Things devices, enabling automatic notifications without human intervention.

As discussed in [6], the integration of web services and the Internet of Things (IoT) has made it possible to manage large volumes of data related to agriculture. With the rapid progress of cloud services and IoT, many effective solutions have been developed for farmers and agricultural areas, resulting in highly efficient outcomes [14].

An intelligent irrigation system that optimizes water utilization using an improved IoT-based strategy is provided in [8] to address concerns about water shortage and improve water use efficiency. It is possible to modify the intelligent irrigation module to suit the unique requirements of different crop kinds. When farmers made agricultural decisions using mobile applications and data from servers was gathered, the system could adjust, offer effective irrigation, and raise in yield.

III. PROPOSED METHODOLOGY

Machine learning algorithms such as supervised learning involve providing the machine with pre-labeled data containing known responses to recognize patterns within the data. This process, known as "training the data," entails analyzing various data types and their corresponding solutions to identify patterns. The accuracy of the results improves with an increase in the volume of data. Subsequently, the next step in supervised machine learning is testing the data. Factors such as noise, outliers in the training data, the dataset's size, and the choice of algorithms can influence the accuracy of the final result. Learning and prediction are the two primary components of any classification process. During the learning phase, the model is developed using the training data, while in the prediction phase, the model predicts outcomes using the training dataset. A reliable classification algorithm can be utilized to interpret and understand decision trees.

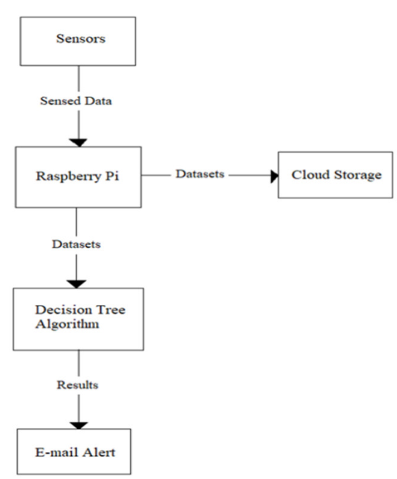

Figure 1: Diagram of Data Flow

The data flow diagram illustrates the flow of data within a system, showcasing the inputs and outputs of its various components. Figure 1 outlines the data flow model for the proposed system.

A. *ALGORITHM*

• One of the most efficient and simple supervised learning techniques is the decision tree algorithm.

• A decision tree is a random unsupervised learning algorithm, used for both classification and regression tasks. It's a hierarchical tree structure, consisting of a root, a branch, an internal node, and a leaf node.

• The decision tree technique is superior to other algorithms in supervised learning because it can efficiently handle a variety of regression and classification tasks.

• Using the available training data, the decision tree approach generates concise, understandable decision rules with the primary goal of building a model that can predict the value or category of the target variable.

• Using a decision tree to produce predictions, one must begin at the root node and assess each record's attribute values to ascertain the class label for that record.

• The decision-making process inside the tree is aided by decision nodes, root nodes, leaf nodes, splinting, pruning, and sub-trees, which follow branch pathways depending on attribute values.

• As the first parent node to split into several groups, the "root node" plays this role.

• Leaf nodes signify the final nodes where splitting stops.

• Decision nodes are sub-nodes that further branch out.

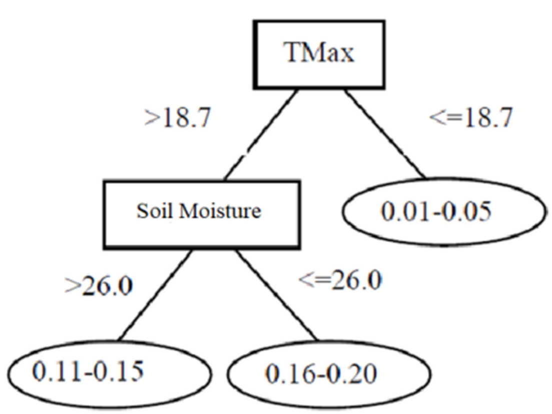

Figure 2. Decision Tree Algorithm

• Splinting denotes the separation of a node into multiple nodes.

• Pruning involves the removal of unnecessary sub-nodes to streamline the tree.

• Sub-trees or branches are integral parts of the decision tree structure.

• When a node branches out from its parent node, it creates child nodes, contributing to the growth of the decision tree.

B. *ARCHITECTURE*

The proposed system design primarily includes temperature and humidity sensors, soil moisture sensors, and an Arduino UNO.

• The Arduino plays a crucial role in the system as it functions as a web server and stores the collected data.

• Figure 3 depicts the installation of a DHT11 sensor and a soil moisture sensor in the field, both connected to an Arduino.

• Data from these sensors is sent to the Arduino UNO for storage and processing.

• The decision tree method is applied to the data sets for accurate predictions.

• The farmer receives email notifications regarding water supply based on the results.

• All sensor data transmitted to the Arduino UNO is archived in a cloud database for future reference.

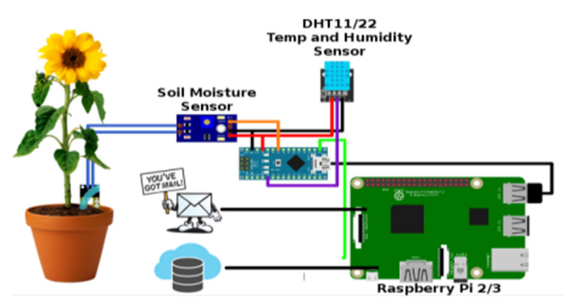

Figure 3: Architecture Schematic

C. *DATASET*

By using the Decision-Tree approach, a node is formed for every attribute in the dataset. The root node contains the most crucial property. To evaluate the job at hand, we begin at the root node and follow the matching node that satisfies our condition or choice as we move down the tree. The decision tree algorithm receives datasets containing information on soil moisture, humidity, and. These datasets encompass values from various environmental conditions to effectively the model. Humidity and soil moisture data are presented as percentages, while temperature is indicated in Celsius. Sample datasets are displayed in Table 1.

S.No	Temperature	Humidity	Soil Moisture
1	36	76	81
2	40	85	70
3	39	73	72
4	41	79	43
5	44	73	65
6	43	75	76
7	36	73	69
8	38	62	48
9	47	67	74
10	51	69	58
11	53	67	45
12	48	93	57
13	49	90	35
14	29	76	67

Table 1: Dataset

The sensors in the environmental monitoring system are designed to collect important information on a variety of characteristics. An ultrasonic sensor uses the reflection of ultrasonic waves to measure distances precisely. Its range ranges from 3 to 350 cm. In addition, the temperature sensor gives information about variations in the surrounding air temperature within a 25 to 50°C range. In the meantime, the soil moisture sensor, which has a range of 0 to 100%, makes it easier to precisely monitor the soil moisture content, which is essential for managing irrigation and determining the health of crops.

Using variations in infrared radiation within its detection range, the PIR sensor provides coverage of up to 7 meters for motion detection. Finally, the humidity sensor, which has a range of 20 to 90%, keeps track of relative humidity levels to guarantee ideal conditions in a variety of circumstances. The accuracy of the humidity sensor will be 50 to 100%. When combined, these sensors provide automated reactions and enable well-informed decision-making in a variety of sectors, including industrial, home security, and agriculture, promoting efficiency and sustainability.

Sensors	Range values
Ultrasonic sensor	3 - 350 cm
Temperature sensor	25 – 50 °C
Soil moisture sensor	0 – 100%
PIR sensor	Upto - 7 m
Humidity sensor	20 – 90%

Table 2: Sensor Range Values

IV. RESULTS

The sample output is shown in Figure 4, together with humidity, water content, and temperature data in both Celsius and Fahrenheit. In addition, it prints the data and alerts the farmer via a registered mobile number.
Applying the decision tree algorithm to the sensed datasets results in an output that includes the choice to water the crop. This output and the decision are sent via a registered mobile number to the users or farmers using the Simple Mail Transfer Protocol (SMTP).

The two types of decisions are called Yes and No.
a) If the algorithm predicts a yes result, the farmer gets the result as shown in Figure 5.

b) If the algorithm anticipates a bad result, the farmer gets a result as shown in Figure 6.

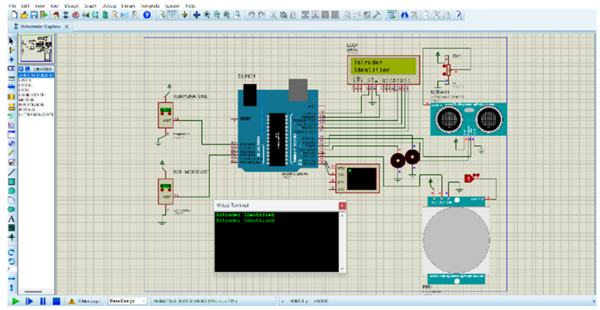

Figure 4: Example Production

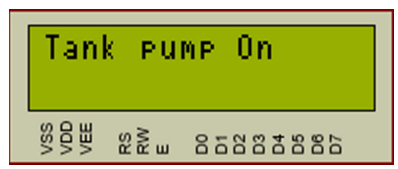

Figure 5: Water requirement alert

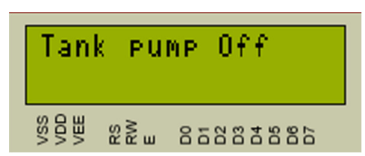

Figure 6: No water requirement alert

The values for water content, humidity, and temperature are also stored in a cloud storage system for later use.

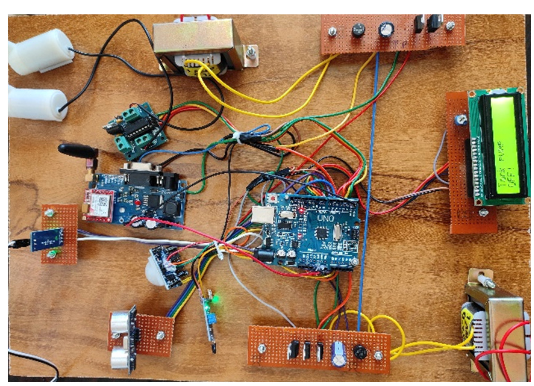

Figure 7: Hardware Kit

In Figure 7, the hardware components are connected to the Arduino UNO in which peripheral devices are connected it. Here, ultrasonic sensor measures the distance between the objects which detect water level in the tank. It receives the distance which is reflected from the obstacles i.e. water. The soil moisture sensor detects the wetness present in the soil which results in reducing irrigation wastages.

V. CONCLUSION

The work presented in this article was largely inspired by the understanding that there will be a severe water shortage in the future. Water is extensively used in agriculture, the primary industry in India. The agricultural industry uses more than 80% of the water resources. Water supplies may soon run out entirely at the current rate. Developing a smart agriculture system with machine learning has several benefits. This kind of technology boosts agricultural production, lowers the risk of disease, pests, and environmental variables, and improves resource allocation by using data-driven insights. Combining sensors, IoT devices, and predictive analytics allows farmers to make well-informed decisions in real time, increasing efficiency and sustainability in agriculture.

Furthermore, the ability of machine learning algorithms to learn instantly promotes adaptability to new agricultural challenges as well as resilience against changing market dynamics and climates. With the advancement and increasing accessibility of technology, smart agriculture has the potential to drastically transform the way we raise livestock, cultivate crops, and manage our land for future generations.

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