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IOT Based Smart Agriculture Using ML

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ABSTRACT:

Agriculture is really important for our country’s economy. India is the second largest producer of agriculture in the world and also ninth largest exporter of agriculture. The rate of agriculture is increasing by 12% per every year. In India farmers use traditional methods for farming, but they face many problems while cultivating. sometimes they may give too much water to the crops, and sometimes they may forget to give water. That’s why we use a smart irrigation system that predicts how much water the crops need using machine learing algorithm. For this the three main parameters are humidity, temperature and moisture to determine the quantity of water required in agriculture field. This system has sensors for humidity, temperature and moisture in the fields. The data is sent to a microprocessor and then to an IOT device with cloud technology. The IOT device used for this is ESP32.The collected data is analyzed using Random Forest algorithm .According to data if the field requries water then ML sends an instruction to the pump control system to start the pump. Once the field get require water then the system instruct the pump control system to stop the pump.

Key words : smart pumps, Random Forest Algorithm, Humidiry, Moisture, Temperature, IOT, Irrigation System.

Introduction:

Water scarcity is a big problem for farming due to droughts and not enough rain. Inthe past, farmers used basic methods like buckets and canals to water their crops, which needed a lot of work and lead to under- or over-irrigation, which can damage crops and waste water. But now, Smart irrigation systems use technology to deliver the right amount of water to crops at the right time. They can help to conserve water and improve crop yields. Machine learning can be used to improve the accuracy of smart irrigation systems. Machine learning models can take into account various factors, such as soil moisture, temperature, and weather, to predict when and how much to irrigate. they use smart irrigation systems that use technology like the Internet of Things (IoT) to control water distribution. These systems are better at saving water and helping crops grow well. These smart systems use things like sprinklers and pipes to give the right amount of water to the plants when they need it. They also use machine learning to know exactly how much water the plants should get. Different types of machine learning techniques, such as random forest algorithm, convolutional neural network, support vector machine, logistic regression are used to make these systems work better. The experimental findings show that the random forest algorithm achieves the highest accuracy of 99.98%in classifying device status, followed by the convolutional neural network with an accuracyof 98.23%. The support vector machine algorithm achieves an accuracy of 90.21%, while logistic regression lags behind with an accuracy of 71.76%.They use data collected from sensors to understand when and how much to water the crop needed. This data can be in different forms like numbers. They also use machine learning methods like logistic regression and random forests to decide if the smart irrigation system is working properly or not.If the system can't know if it's on or off, it might cause problems for the crops. So, we use these algorithms to make sure everything works smoothly in smart farming. The main goal is to make these systems really good at smart irrigation. Researchers have been working on different ways to make farming smarter. I or liamand team in 2020 came up with a clever idea. They used artificial neural networks to understand the soil's nutrients through data from smart soil sensors. Their approach was pretty accurate, ranging from 81.33% to 97.13%.

In 2020, Roy and team developed a system called AgriSens for irrigation. This system, which can be automatic or manual, increased crop production by 10.21%. They thinkin the future, machines using machine learning should figure out how things like wind, humidity, temperature, and UV rays affect crops. In 2019, Neforawati used something called a Convolutional Neural Network (CNN) to figure out the different stages of Paddy growth, like seeding, transplanting, flowering, and maturity. Their classifications were 82% accurate. Similarly, Nindamin 2019 used CNN to tell if Jasmine rice germination was normal or not. Their method was accurate, with a validation accuracy of 96.43%. Building on these ideas from Iorliam, Roy, Neforawati, and Nindam, researchers are suggesting using different machine learning methods like LR (logistic regression), RF(random forest), SVM (support vector machine), and CNN to classify data fromsmart irrigation devices. This classification helps decide if these devices are currently working (ON) or not (OFF). It's like making sure the smart farming gadgets are doingtheir job properly.

Literature Survey:

Paper[1]. This paper is about Automation in agriculture reduces costs and boosts yields. Pfitscher et al. (2011) made an automated irrigation system for rice using wireless tech and SCADA. They used machine learning to classify data from IoT smart irrigation devices, potentially improving crop yields.

Paper[2]. This paper is about Smart Farming .This smart farming system uses IoT and machine learning to make agriculture more efficient. It collects data from field sensors like soil moisture and temperature, using the Naive Bayes algorithm to make predictions. Accurate data from IoT sensors helps give precise irrigation recommendations, addressing water scarcity by optimizing water consumption.

Paper[3]. The paper suggests an IoT-powered drip irrigation system with sensors, a microcontroller, and a cloud network. It allows remote monitoring and controls irrigation based on sensor data. Stable internet is vital. It helps save water and power while increasing crop production. Scalability is crucial for waterNet's success.

Paper[4]. The paper talks about using IoT and ML in smart irrigation systems to manage water in agriculture. They suggest a system that predicts irrigation needs using environmental data and weather forecasts. They train an ML model for better decisions. It helps save water, labor, and nutrients. But they didn't mention cost or feasibility for small-scale farmers.

Paper[5]. The system uses IoT sensors to monitor the ground and surroundings. It analyzes the data and uses machine learning to figure out when to irrigate. Wi-Fi sensors can also measure soil moisture. The aim is to create an efficient irrigation system using IoT and machine learning. Cost-effectiveness wasn't discussed much. It helps save water and increase efficiency. More research is needed to validate its performance in different regions and crops.

Paper[6]. The paper studies smart drip and sprinkler irrigation systems with IoT technology. It analyzes different techniques and their efficiency in conserving water and power. However, it doesn't provide detailed analysis or solutions to the challenges faced, like lack of knowledge and high costs. These systems save water compared to traditional methods. But the sources don't address the challenges in-depth.

Paper[7]. The paper suggests using a drone with a Thermal Infrared camera and GPS to generate thermal images of dry spots in a field. The drone captures images, which are processed onboard. The goal is to selectively irrigate dry areas. However, the paper doesn't mention limitations or challenges with using machine learning for irrigation patterns. Smart sprinklers receive wireless instructions to water specific areas, making water distribution more efficient. The communication range between the ground unit and the drone is 300 to 500 meters, which may limit coverage in open fields.

Paper[8]. The paper proposes a drone with a Thermal Infrared camera and GPS to generate thermal images of dry spots in a field. The drone processes the images onboard to selectively irrigate those areas. However, the paper doesn't mention challenges with using machine learning for irrigation patterns. Smart sprinklers receive wireless instructions to water specific areas, improving water distribution. The ground unit and drone can communicate within a range of 300 to 500 meters, which may limit coverage in open fields.

Paper[9]. The paper proposes an IoTML-SIS for precision agriculture, using sensors to collect data on soil moisture, temperature, humidity, and light. It employs an artificial algae algorithm with an LS-SVM model for classification, increasing efficiency. However, it focuses on limited sensor data and doesn't discuss the impact of environmental factors on the system's accuracy. The IoTML-SIS enables precise irrigation decisions and efficient water resource utilization.

Paper[10]. The paper suggests an IoTML-SIS for precision agriculture, using sensors to collect data on soil moisture, temperature, humidity, and light. It uses an artificial algae algorithm with an LS-SVM model to improve efficiency. However, it focuses on limited sensor data and doesn't mention the impact of environmental factors on accuracy. The IoTML-SIS enables precise irrigation decisions and efficient water resource usage.

Paper[11]. The paper proposes an IoT-based irrigation automation system with a crop recommendation system. Farmers can control the motor remotely based on real-time soil moisture readings. The system collects and analyzes data on temperature and humidity in real-time. However, the accuracy of sensor data is crucial for effective irrigation decisions and crop recommendations.

Paper[12]. The paper proposes a smart irrigation system for agriculture using IoT and machine learning. They use sensors to collect data on soil humidity, temperature, and rain. KNN model performs the best with high recognition rate and low RMSE. The system optimizes irrigation practices, but may not consider crop type and soil composition.

Paper[13]. The paper explores renewable energy integration into smart agriculture to optimize water and energy usage. They found reduced water consumption in a real-world smart farm. However, the system's performance in different regions and accuracy of the machine learning system are still uncertain and being developed.

Paper[14]. The paper talks about the importance of water quality for drinking and irrigation. They propose a network called WaterNet that uses LoRa technology for real-time data collection on water parameters. Machine learning is used to determine water sample suitability. WaterNet provides up-to-date information on water quality, reducing the need for costly lab analysis.

Paper[15]. The paper introduces a flexible IoT-ML platform for precision irrigation tasks. It combines IoT and ML components to provide adaptable solutions. However, it doesn't discuss scaling challenges or security implications, which are important for real-world deployments.

Methodology:

Dataset Description and Pre-Processing:

The paper used publicly available data to analyze and classify smart irrigationdevices.Machine learning algorithms were used to determine if the device was ONor OFF based on features like soil moisture,temperature,humidity and time.The dataset had 100,000 samples, with 70% used for training and 30% for testing.Pythonwas used for programming,and any rows with NULL values were removed duringdata pre-processing by dropna() method.

Methodology:

It Collects raw data from smart irrigation systems.Preprocesses this data to extract information like soil moisture (SM),temperature (T),humidity (H) and time (t).Takes this preprocessed data and uses it as input for four different algorithms (LogisticRegression, Random Forest, Support Vector Machine, and Convolutional Neural Network).Each of these algorithms tries to classify the data,determining if theirrigation system is ON or OFF.The results of these classifications are shownas confusion matrices,which summarize how well each algorithm performed in makingthese classifications.

Logistic regression (LR):

Logistic Regression (LR) is used in this case to classify whether a smart irrigationsystem is turned ON or OFF. It is a type of supervised learning where we have labels for ON (1) and OFF (0). Our goal is to predict if the irrigation systemis either ONor OFF based on certain factors like soil moisture (SM), temperature (T), humidity(H), and time (t).

Random forest (RF):

Random Forest is chosen to classify data from smart irrigation devices because it's known for improving the performance of decision tree classifiers and preventingoverfitting.In this experiment, they used a default of 100 trees in the forest.TheRandom Forest classification method is based on something called the Gini index, which is a way to measure impurity in a dataset.TheGini index formula is given as:

Gini Index = 1 - Σ(Pk^2)

Here's:Pk represents the probability of an object being classified into a specific class. Inthis case, there are two classes: ON and OFF.

The formula calculates the Gini index by considering the probabilities for bothclasses.A lower Gini index means that the objects in the dataset are more consistentlyand accurately classified into their respective classes.

Support Vector Machine:

linear Support Vector Machines (SVMs) can be used to separate data points intotwoclasses, even if the data is not perfectly separable. It does this using a mathematical equation called a hyperplane.This line is defined by the equation $y = ax + b$.Any point above the hyperplane will be classified as +1 class, whereas any point belowthehyperplane will be considered as -1 class.

CNN:

The objective of this experiment is to use CNN to categorize IoT-smart irrigationdataaccording to whether the device is ON or OFF.The first class is denoted bythenumber 1 for ON,and the second class,class 0 is denoted bythe number 0 for OFF.

Evaluation Metrics:

To evaluate the proposed approach, the following evaluation measures are used:

i. Accuracy: Expressed mathematically as:

Accuracy =(TP + TN)/(TP + TN + FP + FN)

ii. Precision: Expressed mathematically as:

Precision =(TP)/(TP + FP)

iii. Recall: Expressed mathematically as:

Recall =(TP)/(TP + FN)

iv. F1-Score: Expressed mathematiically expressed as:

F1 − Score =(2 x Precision x Recall)/(Precision + Recall)

where:

True Positive (TP): The outcome of the developed model correctly predicts thepositive class.

True Negative (TN): The outcome where the negative class is correctly predictedbythe developed model.

False Positive (FP): The outcome where the positive class is incorrectlypredictedbythe developed model.

False Negative (FN): The outcome where the neggative class is incorrectly predictedby the developed model.

Result:

Algorithm	Accuracy	F1 Score	Precision Value	Recall
LR	71.760	0.715	0.730	0.750
RF	99.980	0.999	0.999	0.999
SVM	90.210	0.901	0.901	0.917
CNN	98.230	0.980	0.980	0.980

Here mainly focused on using machine learning to analyze data from smart irrigation devices connected to the Internet of Things. They tried many different algorithms—logistic regression, random forest, support vector machine, and a type of neural network called convolutional neural network (CNN) etc.The results showed that therandom forest algorithm was the best at distinguishing when the smart irrigation device was either "ON" or "OFF," achieving a very high accuracy of 99.98%. This means it was extremely good at figuring out the device's status. This help the farmers to improve crop yields by optimizing the conditions under which the irrigation system operates. In machine learning, especially the random forest algorithm, has great potential in accurately understanding and classifying data from IoT-enabled smart irrigation devices, ultimately contributing to better conditions for crop irrigation and improved crop yields. The another paper proposes a model that gathers raw data from smart irrigation systems, preprocesses it to extract soil moisture, temperature, humidity, and time, and then uses this processed data as input into four separate algorithms (logistic regression, random forest, support vector machine, and convolutional neural network outcomes of these algorithms' classifications are subsequently produced as confusion matrices .Both papers use similar machine learning techniques and input variables for classification, but the other paper provides a more detailed description of the proposed model's functionality as a whole.

Conclusion:

The data generated by Internet of Things enabled smart irrigation equipment can be efficiently classified for agricultural uses using machine learning techniques.Byobtaining high accuracy, F1 score, precision value, and recall, it was discovered that the random forest algorithm was the most effective in correctly differentiating between the periods when the smart irrigation device was "ON" and "OFF". The accuracy and efficiency of these devices in irrigating crop farms is shown by the exact classification of IoT smart irrigation data by machine learning algorithms, which may boost crop yields. This indicates that because of its great accuracy, the random forest algorithm has more potential to evaluate smart irrigation conditions.

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