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Enhancing Crop Water Management: A Logistic Regression Approach Integrated with IoT for Smart Irrigation

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Abstract: This study explores the integration of logistic regression with Internet of Things (IoT) technology to optimize water management in agriculture. Efficient irrigation systems are vital for boosting crop yields while preserving water resources, which is becoming more important due to the growing demand for food and the challenges caused by climate change. The suggested method makes use of Internet of Things (IoT) sensors to gather weather predictions, soil moisture levels, humidity, and temperature readings in real time. In order to determine how much water crops will use, this data is utilized to train a logistic regression model. Supervised learning is made possible by generating labelled data through the analysis of expert knowledge and past irrigation practices. The model's performance is evaluated using metrics such as accuracy, precision, recall, and F1-score. Once validated, the logistic regression model is deployed within the IoT system to provide real-time predictions of crop water requirements. Through automation and data-driven decision-making, farmers can optimize irrigation schedules, minimize water wastage, and enhance crop productivity.

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This integrated approach represents a significant step towards sustainable agriculture and resource-efficient farming practices.

Key words: Logistic regression, Water management, Precision agriculture, Crop water needs, Smart irrigation, Internet of Things.

1. Introduction

Agriculture stands at the intersection of global challenges: ensuring food security for a growing population while mitigating environmental impacts, particularly water usage. In this context, precision agriculture has emerged as a promising approach to optimize resource utilization and crop yields. Central to precision agriculture is the concept of smart irrigation, which leverages progressive knowledges like the IoT to monitor and manage water resources efficiently. By integrating IoT sensors with predictive modeling techniques like logistic regression, farmers can make informed decisions about irrigation, minimizing water waste while maximizing crop productivity. The significance of water management in agriculture cannot be overstated. With water scarcity becoming an increasingly pressing issue in many regions worldwide, it is essential to adopt practices that optimize water usage. Traditional irrigation methods repeatedly rely on fixed agendas or manual assessments, leading to inefficient water allocation and potential over- or under-watering of crops. Smart irrigation systems, enabled by IoT technology, offer a solution by providing real-time data on environmental conditions and crop water needs. By harnessing this data, farmers can tailor irrigation schedules to the specific requirements of their crops, thereby conserving water and improving overall agricultural efficiency.

One of the key challenges in smart irrigation is accurately predicting crops' water requirements based on dynamic environmental factors. This is where predictive modeling techniques like logistic regression come into play. Predicting whether crops will need watering within a specific timeframe is a good fit for logistic regression, a statistical method typically employed for binary classification tasks. More accurate and efficient water management can be achieved by farmers by training a logistic regression model with historical data and real-time sensor readings. This model will allow them to alter their operations and anticipate when irrigation is needed. The integration of logistic regression with IoT-based smart irrigation systems represents a significant advancement in precision agriculture. By combining predictive modeling with real-time data collection and analysis, farmers can optimize irrigation decisions in a proactive manner. This approach not only improves crop yields and resource efficiency but also reduces the environmental impact of agriculture by minimizing water usage and runoff. Furthermore, the scalability and accessibility of IoT technology make it feasible to implement smart irrigation solutions across diverse agricultural landscapes, from small-scale farms to large commercial operations. In summary, the convergence of IoT technology, predictive modeling techniques like logistic regression, and smart irrigation holds immense potential for revolutionizing agricultural water management. By harnessing the power of data-driven decision-making, farmers can mitigate. This paper examines the principles, applications, and benefits of integrating logistic regression with IoT-based smart irrigation systems, highlighting its significance in advancing precision agriculture and addressing the complex challenges facing the agricultural sector.

2. Related Works

A comprehensive literature review in the field of intelligent water irrigation systems has been carried out by the researchers after they have given serious consideration to the strategy, results, benefits, and drawbacks associated with each methodology. In their study [1], Aamo IORLIAM and colleagues have categorized (separated) the data that is created by smart irrigation equipment that is enabled by the Internet of Things (IoT). This accomplishment was accomplished. The researchers propose using pre-processed statistics that are supplied by smart irrigation equipment over the Internet of Things (IoT) as input data for activities that include trend discovery and categorization. This proposal is based on the findings that emerged from their investigation. It was established that the RF approach displayed the highest level of performance among the four machine learning algorithms that were utilized in this inquiry. These algorithms were LR, SVM, RF also CNN. Because of this, it was able to accurately determine whether the smart irrigation device was "ON" or "OFF" with a Recall value of 0.9999, an Accuracy value of 0.998, an F1 score of 0.9998, and a Precision value of 0.9996. Both the quantity and the quality of the data that was used to construct the model are badly deficient. In addition, the researchers have not disclosed any of the dependency parameters that were applied in the process of determining the forecasts of the volume of water. Specifically, this is where the work is lacking. It is not possible to obtain thorough data and samples that demonstrate the amount of water that particular crops require in a variety of situations. Additionally, the sample size is insufficient, which results in conclusions that are not true.In the article [2], Using this strategy, you will have everything you require to construct a measurement or control application in a short amount of time. The incorporation of a rain sensor into the design is even more significant in terms of reducing the amount of electricity that is consumed [3].

According to the authors, farmers can improve agricultural yields and quality while simultaneously reducing overall water usage if they improve soil moisture management across important plant growth periods. Because of this, farmers may now take advantage of the benefits that come with conserving water [4]. It is possible that page-accurate control is not as advantageous to farmers as an embedded system that allows for automated watering in agricultural settings [5]. Farmers are able to increase their productivity while also reducing their expenses when they implement this technique. One of the disadvantages of the system is that it entirely automates the process of watering, and it only employs a few parameters to determine whether or not to water. To further add insult to injury, the publications do not offer an adequate explanation of the quality characteristics that were achieved as a result of the measures taken in the study [6]. This technology is described in the paper [7]. Its acquisition was made possible by a combination of characteristics that encompassed all of the used equipment [8]. It has been demonstrated that the system is capable of using mechanical means. Utilizing sensors that measure moisture, the levels of moisture (water content) that are present in a variety of plants can be determined. In the event that the humidity falls below a predetermined threshold, the Arduino board will be notified by the moisture sensor. The Arduino board will next begin to engage the water pump, which will allow each plant to begin receiving water [9]. This will take place next. The water pump will be turned off and the device will automatically shut down once the required level of moisture has been reached. As a consequence of this, the operation of the system has been subjected to thorough testing, and it is thought that it performs exactly as anticipated. On the other hand, in this particular instance. In addition, the relative humidity is the only component that has an effect on it; other variables that are significant are disregarded [10, 11].

3. Materials and Discussion

The circuit board of an Arduino contains multiple interconnected components that can communicate with one another. The layout has undergone multiple alterations throughout the years, with some of them incorporating new features. The Arduino features additional pins for connecting various components and you can get these pins in two different styles: Points A and B both agree that analogue pins, which can read a broad variety of values, provide for finer-grained control. On most Arduino boards, users can access six of these analogue pins. Getting an expansion board, sometimes called a "shield" that slots into these pins to operate with most items that are compatible with Arduino shouldn't be too difficult after you've bought it. The reason behind this is that a certain configuration of these pins is responsible for this. It is possible to power sensors and LEDs with a low voltage that is supplied by the device itself through a power connection, provided that the power requirements of the attached components are sufficiently low. The power connection can be used to attach an AC converter or a small battery.

The microcontroller, the heart of the Arduino, is what allows programming. To put it another way, it can be taught to execute tasks like following directions and making judgments based on various inputs. The controller is often an ATmel ATmega8, ATmega168, ATmega328, ATmega1280, or ATmega2560, though the precise processor may differ across Arduino versions. This may vary depending on the particular Arduino model you purchase. For an amateur, the most noticeable

distinction between these CPUs will be the variances in onboard memory capacity, though there are a few minor ones as well. The serial connection can be made using the standard USB connector that is included with most modern boards. The board may be remotely updated and communicated with using a USB connection to a computer. Since an increasing number of Arduinos are powered by USB ports, the necessity for an additional power supply is rapidly becoming outdated.
A number of small components in the Arduino board is shown in Figure 1.

Figure 1. Arduino board

Logistic regression is a terrific supervised learning example. This structure's primary function is to predict or determine the probability of a yes/no occurrence. One use of ML is logistic regression, which may be used towards statistically control the probability of a person possessing the COVID-19 virus. There are just two ways to answer this question: infected or not. Binarization is the name given to this sort of classification. Several variables may affect an individual's hypothetical chance of contracting COVID-19. Among these factors are the virus load, symptoms, and antibody levels. While data on viral load, symptoms, and antibodies would be helpful, it's worth noting that these variables are dependent and could affect our results . Logistic regression is useful in many different industries and everyday life contexts. In order to help doctors determine if a tumor is benign or malignant, logistic regression is an option. The financial sector may employ logistic regression to spot suspicious financial transactions. If you want to know how a certain demographic will respond to your marketing efforts, you can use logistic regression. A dataset obtained from Kaggle is utilized for the investigation. The information contained in this collection was obtained from a wireless sensor network device that is actively monitoring and managing an irrigation system at all times. Temperature (in degrees Celsius), humidity percentage, and the amount of moisture that the soil requires are the variables that are included in the approach that has been proposed. The amount of water that is required is determined by the independent variable, whereas the weather conditions (temperature, humidity, and soil moisture) are the factors that are dependent on the independent variable. As a filter, pH is utilized by a number of different filtering systems in order to preserve healthy crop yields in dirty water. The dataset consists of a total of twelve columns and contains literally hundreds of records. Important characteristics include things like the temperature and the amount of moisture present. The flow chart of Intelligent Watering System Design with an Internet of Things (IoT) Kit and Logistic Regression is shown in Figure 2.

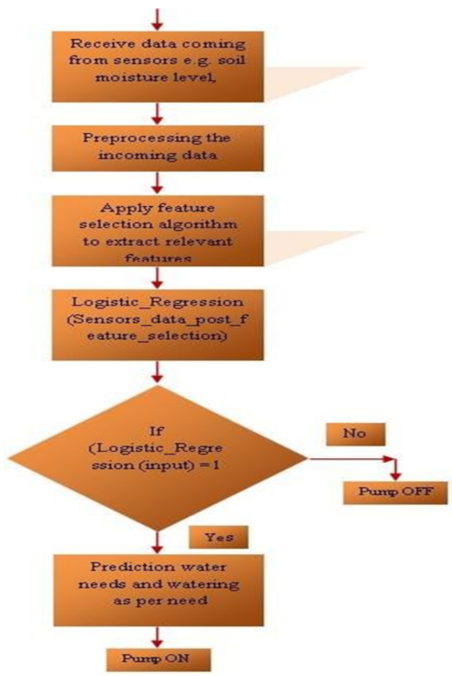

Figure 2. Intelligent Watering System Design with an Internet of Things (IoT) Kit and Logistic Regression

4. Results and Discussion

For the purpose of training the model, we make use of the dataset that was provided by the intelligent irrigation system. Each and every document and piece of information that pertains to the cotton harvest is included in it. During both the training and testing phases of the model, the dataset is utilized. One hundred and thirty percent of the records are included in the testing dataset, whereas seventy percent are included in the training dataset. Through the incorporation of epochs, the accuracy of the model has been continuously increasing over time. This graph, which can be found in Figure 3, illustrates the level of accuracy that was attained throughout the phase of testing the model.

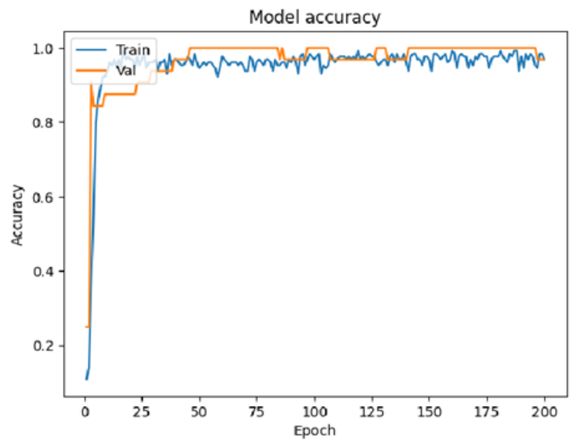

Figure 3. Reliability of the model-Accuracy

The suggested logistic regression model has 97.84% accuracy rate for the dataset's cotton crop when it came to calculating the amount of water needed. The logistic regression approach that incorporates the Arduino-based approach results in more intelligent irrigation systems.

5. Conclusion

In this topic, researchers are working to create fully automated irrigation systems for farms and agricultural fields by utilizing machine learning and circuits based on the Internet of Things. There is no human intervention required to get precise water demand estimations when using the logistic regression methodology, which is detailed here. The solution is both affordable and accessible to all farm owners because all it requires is an Arduino board. Because farmers don't have to physically go out into the fields or operate any other part of this system, they can reduce the amount of physical exertion needed to operate it. An accuracy rating of 97.84% was achieved by implementing the recommended technique. With this precise model, we can automate the water irrigation process and make sure no water goes to waste, both of which cut down on human work. The system's ultimate goal is to facilitate the generation of datasets for a diverse range of crop kinds. This will allow for the testing of models on a wide variety of crop and soil types.

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