Challenges in Information, Communication and Computing Technology – V. Sharmila et al. (Eds)

Exploring advanced learning capabilities in an Internet of Things (IoT) based smart plant irrigation system

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ABSTRACT: As the global population grows, and environmental safety is ever-increasing focus, precision farming plays a critical role in this initiative by increasing agricultural productivity. This study also develops and applies intelligent-machine learning models in the context of an IoT framework via an automatic plant-watering system. The other is in the controlled-environment greenhouses with real-time environmental sensors monitoring the crop conditions and then processed by models such as SVM, RF, CNN, ANN etc. Writer Bio Co-author Ratna Reddy said: "These models estimate agricultural yield and regulate irrigation, revolutionising agriculture. Best for smart agriculture applications, CNN has 98.55% accuracy, same as with ANN and SVM, where also scored high accuracy rates of 88–93%, and RF 90.43% accurate. This method is a step towards promoting data-driven agriculture and sustainable agricultural practices, which will improve the health of a crop and food security.

Keywords: Precision agriculture, smart irrigation, IoT, machine learning, environmental sensors, crop cultivation, CNN, ANN, SVM, RF, crop yield

1 INTRODUCTION

With the help of the Internet of things (IoT), the agriculture field has transformed drastically. Precision water delivery based on plant requirements by smart irrigation systems have improved productivity, resource efficiency and sustainable farming. By using the new technology of artificial intelligence (AI) and machine learning, agriculture today can take

DOI: 10.1201/9781003559085-17

massive data sets from IoT sensors and determine the proper irrigation schedule and make other intelligent decisions. This AI system is capable of predicting future water needs by monitoring the historical data and environmental data also preventing water waste. Challenges related to data reliability, energy consumption, and user adoption remain that require further research in order to effectively leverage advanced learning in agriculture.

2 METHODOLOGY

The article specifies the methodology for developing and researching an IoT-based smart plant irrigation system designed to combine different sensors that are surveiling significant environmental conditions, which determine crop growth. The Figure 1 illustrates that the proposed System Architecture waters the plant based on the sensor data received from Soil moisture, Pressure, temperature and Humidity sensor. This entails deciding on hardware incorporating them into your existing farming system, as well as which sensors to put where in the field. By detecting air temperature, pressure, humidity, and soil moisture, these sensors provide data in real time which enables accurate irrigation control and maximum plant growth. 'The main objective of the system is efficient data collection and communication.' The CPU has a transistor, an Arduino or Raspberry Pi, sensors using Wi-Fi and Bluetooth. This data is then recorded and then sent to a local database for the central microcontroller todo its analysis and processing. It monitors real-time environmental data against pre-set limits, e.g. irrigating when the soil moisture falls below X,urrencriteria. Complex algorithms more accurately simulate irrigation by taking into account past weather, growth phases and other factors. The microcontroller includes these algorithms to guarantee the correct amount of moisture for the plants and reduce water consumption by turning off the pumps when conditions are acceptable. It allows for the irrigation process to be executed smoothly and conveniently via remote monitoring and control.

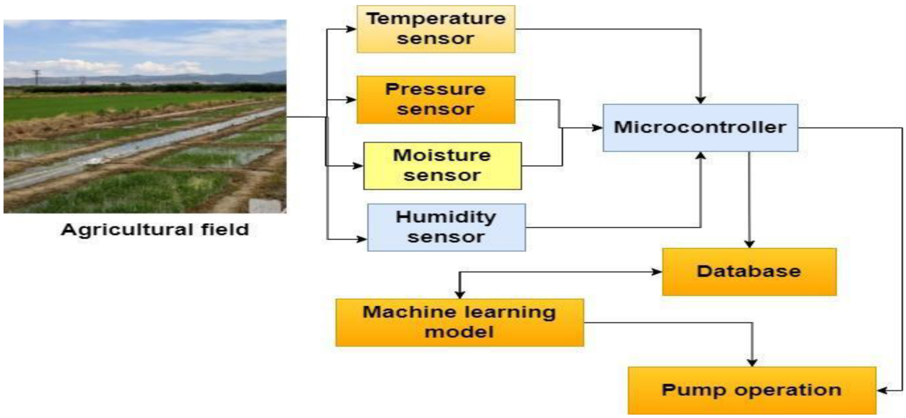

Figure 1. Architecture of the proposed system.

3 VARIOUS SENSOR USED IN THIS RESEARCH

The Internet of Things (IoT) relies on various sensors to provide accurate and efficient data for decision-making in plant irrigation systems. Temperature sensors are crucial in monitoring outside air temperature, which impacts plant growth. Barometer sensors predict weather patterns by monitoring barometric pressure, helping adjust watering schedules to avoid overwatering. Hygrometers measure humidity levels, ensuring proper watering and preventing moisture-related plant diseases. Soil moisture sensors, utilizing TDR principles, adjust water usage based on real-time data, increasing irrigation system stability and efficiency. Customizable sensors help conserve resources in water-scarce areas. These sensors work with microcontrollers and data acquisition systems, providing critical information for effective irrigation management. Overall, the adaptability and accuracy of these sensors play a vital role in optimizing plant irrigation systems and promoting sustainable agriculture practices.

4 NEED FOR MACHINE LEARNING

Modern irrigation systems, which are vital for crops such as rice, now consist of prediction algorithms that take into account temperature, pressure, humidity, etc., and create the optimal schedules for watering. By stopping your system from over-watering, problems, such as soil erosion, root rot and reduced water efficiency leading to unhealthy plants, are avoided. This approach is highly effective in water deprived areas with maximum plant growth, and minimum resource utilization.

5 VARIOUS MACHINE LEARNING MODEL USED IN THIS RESEARCH

Modern agricultural irrigation systems, which utilize a wide variety of environmental sensors to generate and analyze data that machine learning algorithms train on, are able to optimize water utilization imbibing crop productivity while minimizing the loss of resources. The model help determine when and how much water to provide for crops. We experiment with multiple important machine learning models in this research such as Artifiacial Neural Network (ANN), Convolutional Neural Networks (CNN), Support Vector Machines (SVM) and Random Forests (RF). As for simply watering your plants intelligently, each one of these would be good options depending on what you wished to use it with and what its other capabilities were.

5.1 *Artificial neural networks (ANN)*

Machine learning uses neural networks extensively, which is a biologically inspired network that resembles how the human brain works. Artificial neural networks (ANNs), are conformed by layers of artificial neurons assembled with the purpose to process data, detecting patterns and to elaborate complex characteristics Not Supported Exception. Flat Appearance. Firstly, artificial neural networks (ANNs) are highly flexible and can be easily applied to various applications such as speech recognition, text/picture analysis etc., and with this situation – irrigation system prediction modeling. Artificial Neural Networks (ANNs) and other machine learning models based on sensor data, temperature, pressure, humidity and previously measured soil moisture levels can be used to predict the future values of Soil Moisture in smart irrigation. “Our method is that the networks learn the correlations of various environmental conditions with how close or far away we are from achieving a given soil moisture target, which allows them to predict how quickly they’ll get there,” he said. And ANNs are also able to capture non-linear interactions, and much like the cubs brain they can recalibrate over time if so desired.

5.2 *Convolutional neural networks, or CNNs*

One type of artificial neural network, are used in analyzing visual inputs. For example, a CNN can take an image as input and identify objects or animals it depicts. Critical for jobs looking at agricultural images to try and identify but maybe not the best option re: predicting soil moisture. For example, CNNs could inspect the images of plants sent in by cameras inside an irrigation system that monitors crop conditions. Disease, stress or pests are recognized by these networks via visual signals. Early detection and treatment of plant problems by CNNs could increase the health and output of crops as well. That is, CNNs can be used to estimate the moisture content of soil from images with picture or satellite representation in order to investigate how site specific changes are reflected by moisture content.

5.3 *Support vector machines, Or SVMs*

Support Vector Machines (SVM) is a subset of supervised machine learning models which is widely used for regression and classification purposes. SVMs try to find the best (maximum margin) hyperplane that separates data points of different clasess It is possible to predict the essential factors such as possibility of rain or upcoming draught in case of smart irrigation with the help of SVMs. For example, by using historical meteorological data with temperature, pressure and humidity etc., SVMs can help in finding and predicting a weather which is suitable or unsuitable for irrigation. In addition, if a drought is expected or it's going to rain, the system will adjust its schedule accordingly. This measure even provides a call to proactive management and conservation of resources.

5.4 *Random forests (RF)*

A Random Forest (RF) is an ensemble learning technique that combines multiple decision trees to make predictions, and then the majority vote and average determines the results with a random subset of features and data. Data-centric functions also the where RF-based irrigation systems shine, by identifying and focusing on the environmental variables that affect soil moisture most in a field. We were able to do a great job with support vector machines, but they do not tend to work well with noisy data or are prone to overfitting, and they generally fail in real-world agricultural applications in heterogeneous data. Combining the two above-mentioned models – ANN for soil moisture prediction and SVM for weather forecasting – into hybrid models results in high performance due to large number of parameters functioning together. The methods have had technical promise, but face challenges of requiring high-quality, tagged training data, a manual effort often entailing high cost/time. Given that agricultural decisions are made by human experts, the interpretability of the results is very important; they need to understand the model predictions and confirm them. Function within fluctuating conditions, including different growing seasons, crop types, and weather patterns. Their use in real-world operations means that regular updates and retraining must take place. Design Prettiness Problem-solving Useless One hit wonder Models should deliver against a whole set of problems.

6 RESULT AND DISCUSSION

One of the key point to create rice is by controlling and monitoring soil dampness, temperature, pressure, moist conditions in this way essential for development of a particular harvest. Before that, I have trained machine learning models on the real-time data from sensors and use them to predict and control smart irrigation systems Use such models to predict irrigation requirements and crop output, efficiently use resources and enhance the overall health of crops. Lastly, the machine learning models' effectiveness is assessed as an irrigation management and crop forecasting tool. As shown in Figure 2, Convolutional Neural Networks (CNN) have the highest accuracy at 98.55%. Additionally, ANN, SVM and RF models are trustful to give the predictions in irrigation system as well. CNN outperformed other models because of its capability to identify intricate patterns in data, so it is the most useful model for plant irrigation systems (Figure 3). To sum up, machine learning models are vital in boosting agricultural production and smart irrigation by allowing better water management.

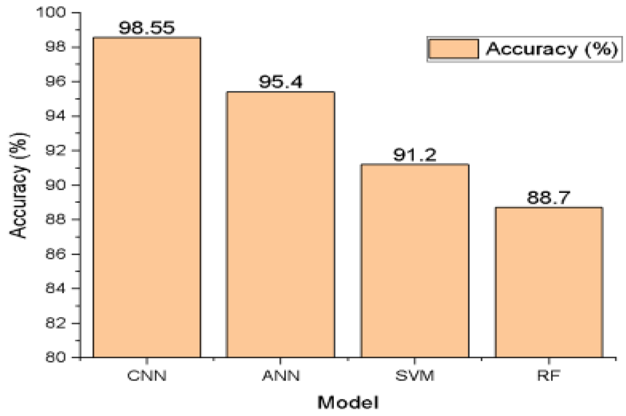

Figure 2. Accuracy of model.

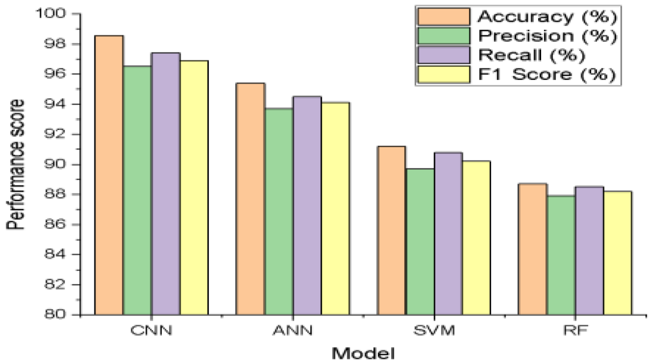

Figure 3. Performance score of each machine learning model.

7 CONCLUSION

In conclusion, this research demonstrates how data-driven precision agriculture and smart plant breeding technologies could revolutionize the agricultural sector. Important insights on crop decisions: these can be derived from various Sensors and machine learning model like irrigation management. “The prediction algorithm, which can be obtained using a large dataset, has been successful in achieving high accuracy rates for predicting crop yield as well as the conditions of irrigation motors.” Performance of CNN and other models such as Random Forest (RF), Artificial Neural Network (ANN) and Support Vector Machine (SVM) is given in the study itself this research further highlights the use of precision, recall and F1 index for achieve a compromise between accuracy and recall to reach maximum crop health as well as yield in sustainable agriculture. This work paves the way for future technologies in precision agriculture that will improve food security, resource conservation and productivity of farming as we pursue success in our mission to grow more with less.

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