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Hydroponics Integrated with Machine Learning

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ABSTRACT:

Hydroponics with Machine learning represents a comprehensive initiative aimed at addressing the challenges encountered by both farmers and practitioners of hydroponics, a modern agricultural method. This method is particularly effective for growing certain types of plants, such as leafy vegetables, berries, greens, and tomatoes. The project's primary focus is to support farmers by combining our machine learning model with their IoT devices and hydroponic systems. This integration enables the monitoring of plant growth and the parameters influencing it, with a special emphasis on tomatoes, and offers personalized support to users who may not be familiar with advanced agricultural technologies. Improving crop productivity, this approach can lead to better yields and more nutritious food. Key features of this project include personalized support for users—both farmers and others utilizing hydroponic systems—through notifications and suggestions aimed at enhancing plant growth. Additionally, the project boasts a user-friendly interface for both administrators and users. Our goal is to tackle issues associated with traditional farming techniques by offering structured and personalized solutions that have the potential to make a significant impact in the agriculture sector.

I. INTRODUCTION:

Hydroponics is a soil-less way of cultivating crops in water, as one of the potential agricultural approaches. It provides various opportunities in agriculture, particularly in locations coping with issues such as uncontrollable soil deterioration and limited water supplies. Furthermore, this agricultural practice demonstrates excellent results towards an environment-friendly and user-friendly farming and a reliable tool to address food security. Temperature, humidity, water levels, NPK (nitrogen, phosphorus, and potassium) sensors and automatic irrigation are the most important factors in agricultural productivity, growth, and quality.

Hydroponics, particularly the Nutrient Film Technique, is gaining global interest, attracting substantial investments, with the Indian market expected to achieve a 13.53% annual growth rate by 2027. The absence of soil allows crops to grow directly in nutrient solutions, and the term "hydroponics" reflects the water-centric nature of this method. IoT plays a crucial role in hydroponics, enabling automated plant cultivation by monitoring and regulating factors such as H2O level, pH, humidity, temperature, and light intensity. The use of technology, including Artificial Neural Networks (ANN), contributes to plant growth predictions, considering elements like temperature, light intensity, electrical conductivity, and the age of the plant.

In connection with the advent of big data technologies and high-performance computing, Machine Learning(ML) has emerged to create new possibilities for data-intensive science in the multidisciplinary Agri-technologies domain . Farm management systems are turning into real-time artificial intelligence enabled programs that provide comprehensive recommendations and insights for farmer decision support and action by using ML to sensor data.

II. BLOCK DIAGRAM:

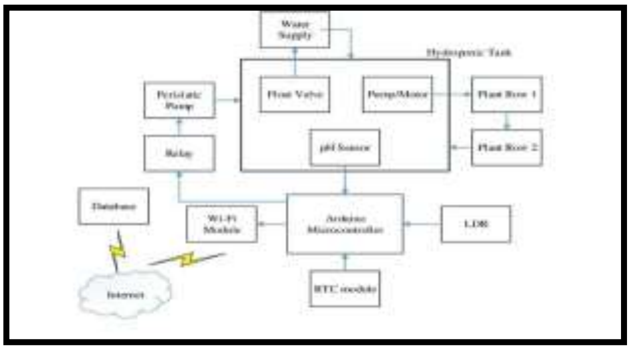

Fig 1: Developing Interface

Overall, this study emphasizes that developing an interface for hydroponics farming using IoT with input fields such as Temperature, Humidity, Light Intensity, pH Level, Plant Height, Water Level, Nutrient Concentration, Leaf Width, Stem Width, and CO2 Level, and integrating machine learning (ML) algorithms for pattern detection can greatly enhance the efficiency and productivity of hydroponic systems.

III. HYDROPONICS INTEGRATION:

Hydroponics farming using IoT will lead to improved efficiency and productivity in managing hydroponic systems

This study focused revolutionize tomato cultivation by integrating cutting-edge technologies, optimizing resource usage, improving crop quality, and promoting sustainable and economically viable farming practices.

Optimizing Resource Efficiency: *The use of the Nutrient Film Technique, coupled with Deep Neural Networks, ensures precise and efficient nutrient management. This targeted approach maximizes water efficiency, reduces the ecological footprint, and minimizes economic investments in terms of water usage.*

Enhancing Crop Production: *The project aims to achieve high-quality plant growth and increased root development, leading to a significant boost in crop production. The use of technology, such as Deep Neural Networks, allows for accurate and informed decision-making in managing the hydroponic environment.*

1. NUTRIENT FILM TECHNIQUE:

A properly designed NFT system is based on using the right channel slope, the right flow rate, and the right channel length. The plant roots are exposed to adequate supplies of water, oxygen, and nutrients. In earlier production systems, there was a conflict between the supply of these requirements, since excessive or deficient amounts of one result in an imbalance of one or both of the others.

NFT, because of its design, provides a system wherein all three requirements for healthy plant growth can be met at the same time, provided that the simple concept of NFT is always remembered and practiced. The result of these advantages is that higher yields of high-quality produce are obtained over an extended period of cropping. A downside of NFT is that it has very little buffering against interruptions in the flow, such as a result of a power outage. But, overall, it is one of the more productive techniques. [citation needed]

NFT's benefits extend beyond resource efficiency. Its continuous recirculation of nutrient solutions minimizes waste and provides an eco-friendly solution. The reduced risk of soil-borne diseases, as plants never come in direct contact with soil, ensures a cleaner and healthier growing environment. NFT systems are easily automated, allowing for precise regulation of nutrient flow and pH levels. This automation, coupled with the system's adaptability to various crops, contributes to faster plant growth, quicker harvest cycles, and versatility in agricultural applications. In essence, NFT in hydroponics represents a sustainable, space-efficient, and highly controllable method that facilitates optimal

Fig2: plant Development

Chemical nutrients used in hydroponics:

In hydroponics, the following chemicals are commonly used:

1. Nutrient solution - a mixture of essential minerals and nutrients that plants need to grow, such as nitrogen, phosphorus, potassium, calcium, magnesium, and sulphur.

2. PH adjusters - to regulate the pH levels of the nutrient solution and ensure that it falls within the optimal range for plant growth. Common pH adjusters include sodium hydroxide and phosphoric acid.

Water conditioners - to remove chlorine, heavy metals, and other impurities that may harm the plants.

3. Silica - to improve the strength of the plant structure and enhance its resistance to pests and diseases.

4. Hydroponic hormones - such as auxins and cytokinins, promote root growth and regulate plant development.

Fig 3: Chemical Mixture

IV. METHODS:

- ***Data Collection Module:***

Description: Responsible for collecting real-time data from sensors and IoT devices deployed in the hydroponic system.

Functionality: Acquires sensor data on nutrient levels, water flow, environmental conditions, etc. Utilizes IoT devices for seamless data transmission.

- ***Data Preprocessing Module:***

Description: Cleans and preprocesses the raw data collected from sensors before input into the Machine Learning model.

Functionality: Handles normalization, noise reduction, and feature extraction. Prepares the data for analysis and prediction.

- ***Machine Learning Model Module**:*

Description: The core software module responsible for training models to predict optimal nutrient levels, water flow, and environmental conditions.

Functionality: Utilizes machine learning algorithms (without specifying model names) to analyze sensor data and make predictions. Adapts to dynamic changes in the hydroponic environment.

- ***Optimal Control Module:***

Description: Focuses on adjusting parameters based on predictions from the Machine Learning model.

Functionality: Implements a real-time monitoring and control system using software algorithms. Automatically adjusts parameters for an ideal growing environment.

- ***Database Module:***

Description: Stores historical and real-time data generated by the hydroponic system for analysis and reference.

Functionality: Ensures secure and scalable storage of data. Supports retrieval for historical analysis and optimization.

A Gradient Boosting Decision Tree (GBDT) is a decision tree ensemble learning algorithm similar to random forest, for classification and regression. Ensemble learning algorithms combine multiple machine learning algorithms to obtain a better model.

Both random forest and GBDT build a model consisting of multiple decision trees. The difference is in how the trees are built and combined.

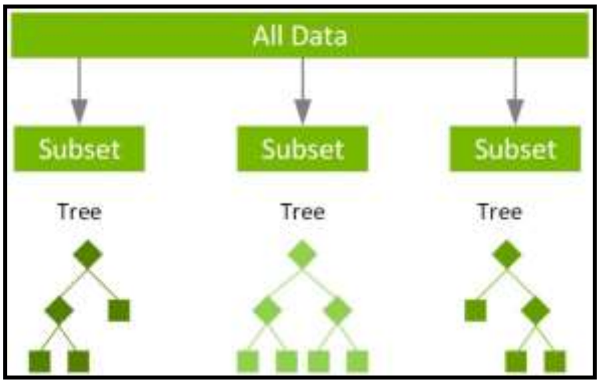

Fig 4: multiple decision trees of subsets

Random forest and gradient boosting are popular machine-learning techniques with distinct approaches. In random forest, multiple decision trees are built simultaneously from different subsets of the dataset using a technique called bagging. Each tree predicts an outcome, and the final prediction is an average of all these individual tree predictions. This helps reduce overfitting and improves overall model performance.

On the other hand, gradient boosting focuses on iteratively improving a single weak model by combining it with several other weak models. This is done through a process similar to gradient descent, where the objective is to minimize errors. Gradient boosting sets targeted outcomes for the next model based on the gradient of the error, aiming to minimize bias and underfitting. The final prediction is a weighted sum of all tree predictions.

V. CLASS DIAGRAM:

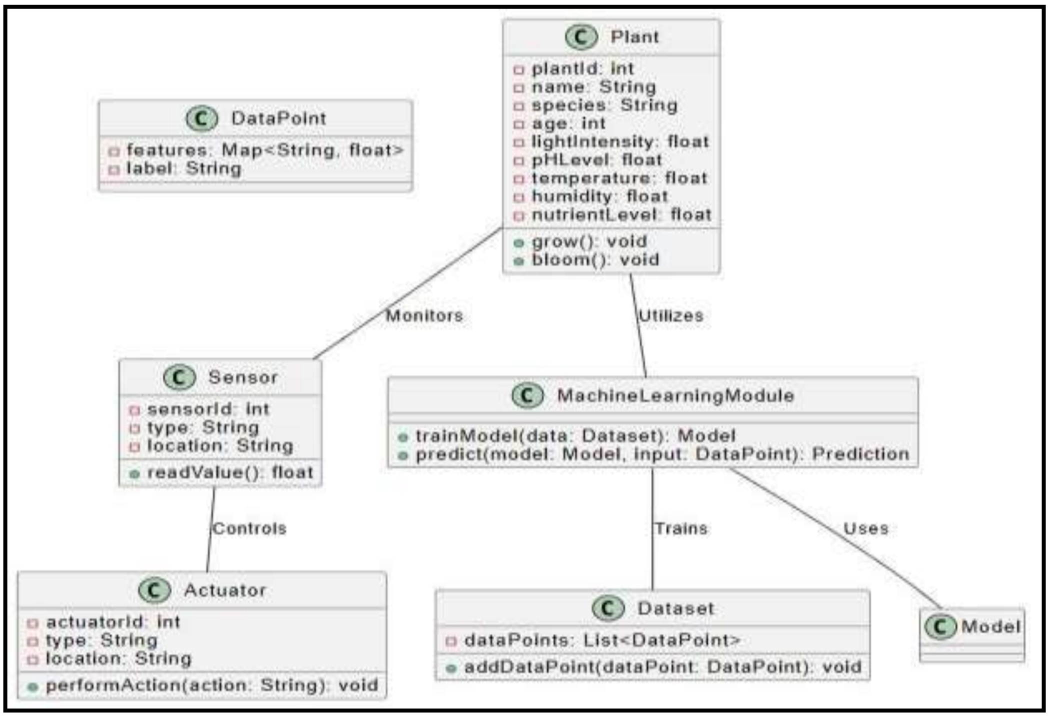

Fig 5: Layout of the Model

VI. RESULT AND ANALYSIS:

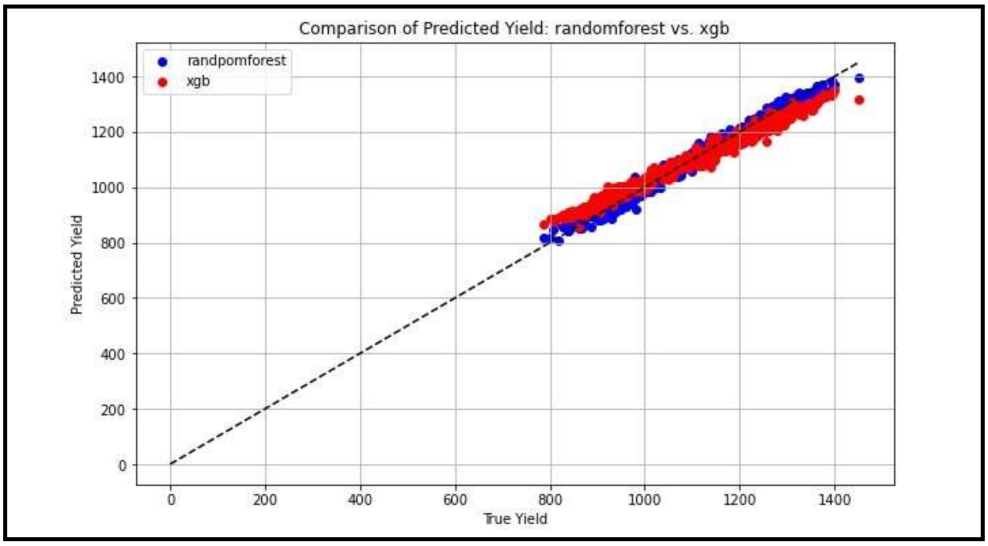

Fig: comparison of predicted yield between, random forest and xgboost (xgb).

The is a line graph showing a comparison of predicted yield between two models, random forest and xgboost (xgb). The red line represents the predicted yield from the random forest model, and the blue line represents the predicted yield from the xgboost model.

However, as the true yield values increase, the predictions from the two models start to diverge. The random forest model tends to predict higher yields than the xgboost model for higher true yield values.

It is important to note that this graph is only showing predictions for a specific scenario. The accuracy of the two models could vary depending on the specific data that is used to train the models.

VII. CONCLUSION:

Hydroponics integrated with machine learning with IoT devices represents a critical advancement in the field of agriculture. This sector, often get overlooked and needs modernization and good innovations. This approach promises enhanced productivity in plant growth and offers solutions to address agricultural challenges. It addresses issues such as limited land availability, soil erosion, degradation, and water scarcity, and it can also be applied indoors, contributing to the decrease of global food availability concerns.By combining machine learning with IoT for real-time environmental monitoring and control, with the predictive capabilities of ML algorithms, this system is beneficial to generate better outcomes. Continued investment in research and development in this domain is crucial and the project can be expanded in future with the advancement in technology. Promoting the advancement of machine learning, IoT, and hydroponics in agriculture is imperative to ensure food security and uphold environmental sustainability for future generations.

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