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A Data - Driven Crop Recommending System Using IoT and Machine Learning

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Abstract. This study explores how modern technologies like the Internet of Things (IoT) and machine learning can make farming smarter and more efficient. The proposed system brings together three important aspects of agriculture: choosing the right crop, recommending suitable fertilizers, and managing irriga- tion automatically. By analyzing factors such as soil conditions and environmen- tal data, the system helps farmers decide which crops are most likely to grow well in their fields. It also suggests fertilizers based on the specific needs of the crop and the nutrients already present in the soil, which can improve yield and reduce waste. In addition, the irrigation system uses real-time soil moisture data along with weather forecasts to provide the right amount of water at the right time, avoiding both overwatering and water shortage. The system was tested through simulations, and the results show that it can be a practical and effective solution for improving agricultural productivity.

Keywords: Artificial Intelligence, Crop Recommendation, Irrigation System, Fertilizer Recommendation.

1 INTRODUCTION

ML and IoT-based agricultural systems are being developed to enhance farming practices. The focus is on an intelligent system.? Read more. The system is intended to perform essential agricultural tasks, including selecting appropriate crops, automating irrigation, and suggesting fertilizers. It is designed to reduce manual labour, save energy and increase farm productivity.

A thorough background check is conducted to determine the need for intelligent farming solutions. Its system will not only increase crop yield but also help with better rotation planning of crops, improve land management and use more water through tar- geted irrigation. Using IoT and ML, a cost-effective smart farming model is proposed to improve accuracy and reliability through modern means.

One area of interest in the research is how machine learning can be used to improve precision agriculture, especially in crop farming and food systems. The assessment of various ML models is conducted to determine the most appropriate ones for farming. The research also investigates the potential application of algorithms to sensor-gener- ated data in agricultural contexts. A practical application of an IoT-based smart farm prototype is presented as evidence of its usefulness.

The research also includes an advanced system that employs deep reinforcement learning within an IoT context.. This system has multiple layers including edge devices, communication networks, data collection units and cloud platforms. Its aim is to greatly enhance productivity and efficiency in agriculture by integrating artificial intelligence, cloud computing, and other technologies.

The application of an algorithm focuses on crop recommendation by considering the significance of soil nutrients such as nitrogen (N), phosphorus (P), and potassium (K). Inputs such as temperature, humidity and soil moisture are used to determine optimal irrigation schedules using a decision tree model. According to the study, farming deci- sions can be optimized by utilizing Support Vector Machines (SVM) in conjunction with decision trees.

The study focuses on the application of machine learning and computer vision tech- niques to evaluate crop quality and yield. These techniques aid in the classification of cropped images and monitoring plant health. The proposed system includes a full- fledged process that involves collecting data via sensors, processing and storing it, and applying AI for predictive analytics, all with the help of wireless sensor networks.

The research provides a framework for setting key performance indicators (KPIs) in precision agriculture. Machine learning-based predictive model called WPART is in- troduced, which uses IoT to forecast crop yield and detect drought conditions. Addi- tionally they also propose an IoT-based, intelligent irrigation system that uses Long Short-Term Memory (LSTM) networks for quick and accurate water delivery.

By examining various factors, including soil characteristics, weather patterns, and crop demands. The system developed in this study builds upon previous research to provide crop recommendations. External APIs are utilized to integrate features such as automatic irrigation and weather forecasting, making the system more adaptable.

This paper has been divided into several parts. First, environmental problems in ag- riculture and why are there solutions. The system's design methodology and technolo- gies are outlined in the second part of this article. Three key elements are outlined in the third part: crop forecasting, automated irrigation, and fertilizer guidance. Machine learning, weather data, and crop characteristics are used to describe each component. In the following section, we examine the outcomes of system simulations and conduct analysis to understand their performance and potential applications in real-world sce- narios. Additionally,To conclude, the paper summarizes the main results of this study and highlights the importance of integrating IoT with machine learning in the agricultural sector. It pro- vides information on potential improvements and research advancements. All in all, this work shows that advanced technologies can play an important role to make farming more efficient sustainable and more productive.

2 METHOD PROPOSED

Developing a system that integrates various agricultural functions in order to max- imize crop productivity is crucial. The suggested approach involves the use of a crop recommendation module, an automated irrigation system, and aided fertilizer guidance system.

Farmers can use the crop recommendation tool, which analyzes soil characteristics and local weather patterns, to determine the most appropriate crops for a particular area and improve their planting practices. The irrigation component utilizes soil moisture and weather data to determine the appropriate watering schedule for crops. At the same time, a module on fertilizer use advises: "What variety, amount and when should I apply fertilizers; to promote healthy plant growth as well as optimal utilization of its precious nutrients.".

The integration of these three elements into one system improves the overall effec- tiveness and health of crops while promoting higher productivity.

2.1 System for Recommend the Crops:

The system starts by obtaining crucial environmental and soil data for a particular site. Dedicated sensors are used to measure key soil properties, such as pH and NPK, as well as temperature, rainfall, and soil moisture. A cloud-based platform is used to process weather-related data, which is obtained from an open weather API.

Following the gathering of all data, a machine learning pipeline is utilized to deter- mine which crops are optimal for given conditions. First, the data is clustered and grouped using techniques of clustering, before various machine learning models are used to test performance. The models consist of Random Forest, Gradient Boosting, Decision Tree, Extreme Gradent boosting (XGBoost), and K-Nearest Neighbors (KNN). To determine the most effective approach, their results are compared.

At last, data from sensors and the cloud is transmitted and synchronized effectively for analysis. By means of this comprehensive evaluation, the system suggests crops that will grow best under the specific environmental and soil conditions in the area.

2.2 Automatic water pouring system:

This smart irrigation system uses a combination of sensors and modern technologies to improve watering efficiency and support healthy plant growth. It includes soil mois- ture sensors to continuously track the level of moisture in the soil, along with weather data collected from cloud-based services such as open weather APIs. Flow sensors are also used to measure how much water is being delivered, while temperature readings are recorded at regular time intervals.

The system works by analyzing both soil conditions and upcoming weather patterns. When it detects that the soil is too dry and there is no rainfall expected, it checks the current temperature. If the temperature is within a normal range, the system activates the pump for a short duration to meet the minimum water needs of the crops. However, if the temperature is higher than usual, the system increases the watering time to ensure the plants receive sufficient moisture. On the other hand, if rain is predicted, the system delays irrigation, allowing natural rainfall to take care of watering and preventing un- necessary water usage.

A microcontroller manages the entire process, making real-time decisions based on inputs from the sensors, the size of the field, and the specific water requirements of the crops being grown. This ensures that plants receive neither too much nor too little water. Overall, this intelligent irrigation approach helps maintain the right balance of mois- ture in the soil, adapts to changing environmental conditions, and improves crop health. By optimizing water usages and reducing waste, it contributing to more suitable and efficient farming practices.

2.3 *Fertilizers Suggesting system:*

Soil fertility plays a key role in determining how well crops grow, as it depends on the availability of essential nutrients such as nitrogens (N), phosphores (P), and pota- sium (K). To accurately measure these nutrients, the system uses an NPK sensor that captures real-time soil data. Since different crops require different nutrient levels, the collected data is analyzed based on the specific crops were been cultivated.

The system compares the measured nutrient levels with the ideal requirements for that crop to assess soil quality. If the nutrient balance is already sufficient, it suggests continuing with standard fertilization practices to maintain soil health. However, if the nutrient levels are lower than required, the system recommending additional fertilizer tailored to meet the crop’s needs.

It also provides guidance the correct quantity and timing for fertilizers applicants, help- ing farmers avoid both underuse and overuse. By offering precise and crop-specific recommendations, this system supports better soil management and ensures consistent crop growth throughout the entire cultivation period.

3 DISCUSSION & RESULTS

The resourced model to have underlying simulation, and these section presents the finding:

3.1 Crop Recommending System:

Table 1. Models and there accuracy related.

S. No.	Model	Accuracy	Train Accuracy
1	DT	0.99187	0.999521
2	GBC	0.9961	0.999873
3	KNN	0.97895	0.989204
4	RFC	0.99816	0.999942
5	XGB	0.99276	0.999688

Table1 provides a detailed comparing for accuracy levels achieved by the five dif- ferent machine learning models. The results show that the K- Nearest Neighbor (KNN) algorithm performs quite better than other models on this dataset. Based on this out- come, KNN is selected as the most suitable approach for use in the crop recommenda- tion system.

```
Enter the Value of N : 37
Enter the Value of P : 34
Enter the Value of K : 30
Enter the Value of pH : 6.79
Enter the City : Delhi
Crop Suggested : Banana
PS C:\Users\ehskusa\OneDrive - Ericsson\Documents\VScode\ML\NumPy>
```

Fig. 2. Simulations for Crops Recommending System.

Figure 2 illustrates the key input parameters used by the system, including soil pH and the levels of required nutrient such as nitro (N), phosphores (P), and potasium (K). In addition to soil related data, the system also collects important weather infor- mation—such as humidity related, rainfall parameters , and temperature pointers— from a cloud platform based on the selected city.

For combining both soil and environmental data, the K-Nearest Neighbors (KNN) model analyses the conditions and determines the most compatible crop for that loca- tion. This integrated approach enables the system to generate accurate recommenda- tions, such as suggesting a crop like oranges when the conditions are favorable.

Table 2. Crop Recommending and its different atmospheric Pointers.

N	P	K	temperature	humidity	pH	rainfall	label
91	43	42	20.965432	81.87456	6.49877	203.12875	rice
72	55	17	22.548912	63.41279	5.76234	88.124569	maize
14	59	24	17.389521	20.84561	5.70123	129.48756	kidneybeans
4	48	17	27.845673	64.5322	3.74561	33.215478	mothbeans
18	56	21	27.612345	87.94213	7.12346	55.672134	mungbean
57	78	16	29.672134	62.84322	7.49877	72.456781	blackgram
3	25	39	24.789345	90.87456	5.87234	110.94567	pomegranate
92	45	47	29.784563	76.54322	6.20123	93.215478	banana
118	26	52	26.912345	81.56438	6.35432	54.128945	watermelon
116	18	54	27.684521	93.84216	6.78901	28.945612	muskmelon
25	127	195	22.845673	91.23457	5.61235	111.87456	apple
23	31	11	15.965432	91.84561	6.28765	120.45679	orange

Table 2 highlights how the crop prediction system provides different recommenda- tions across a variety of data inputs, demonstrating its ability to adapt to changing en- vironmental conditions. This flexibility allows the system to generate more personal- ized crop suggestions, helping farmers make better decisions and ultimately improving productivity and yield outcomes.

3.2 Automatic water system:

Table3 shows the watering requirement for different crops, including the recom- mended moisture range (in millimeters) needed for good growth. This system ensures soil moisture stays within this optimal range so that crops can develop properly.

To manage this, the system takes inputs such types of crops been grown and the location (city). It then uses a cloud platform to collect relevant weather data, including temperature and rainfall, which helps in making accurate and timely irrigation deci- sions.

Table 3. Watering requirement for Different Crops.

Crop	Minimum (in mm)	Maximum (in mm)
Apple	820	1210
Banana	1080	1225
Coffee	210	315
Cotton	520	940
Grape	780	320
Maize	370	1480
Orange	420	400
Rice	1180	920

3.3 *Fertilizer Predicting System:*

Healthy plant development depends heavily on maintaining the right balance of es- sential soil nutrients—nitrogen (N), phosphorus (P), and potassium (K). To achieve this, the system evaluates the levels of these nutrients and provides fertilizer recom- mendations accordingly.

It starts by gathering real-time N, P, and K values from the soil through an NPK sensor, along with details about the specific crop being cultivated. Based on this infor- mation, the system determines the most suitable fertilizers and the appropriate amounts required. By regularly tracking changes in soil nutrient levels, it ensures that crops are supplied with the necessary nutrients at the right time, promoting stronger growth and higher yields.

4 CONCLUSION

A smart agricultural system has been developed to provide crop recommendations based on local climate conditions and soil properties. In addition to suggesting suit-able crops, the system also automates irrigation when needed and offers fertilizer recom- mendations tailored to each crop type. It is designed to support a wide variety of crops, such as rice, grapes, maize, cotton, apples, bananas, coffee, and oranges, helping farm- ers achieve better results.

By using this system, farmers can make more informed decisions, reduce manual effort, conserve energy, and improve overall productivity. Looking ahead, the sys-tem can be further enhanced by adding a disease prediction feature that uses image-based analysis to identify potential crop diseases. This improvement would make the system even more effective and contribute to more sustainable and efficient farming practices.

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