Smart Fields: Enhancing Agriculture with Machine Learning

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Abstract - Agriculture is a cornerstone of India's economy, supporting a vast majority of its population. However, farmers grapple with selecting the right crop due to diverse soil characteristics, environmental factors, plant diseases, and the need for consistent crop monitoring. This paper presents a smart system assisting farmers in specific crop selection, integrating plant diseases and consistent monitoring as vital features. By considering comprehensive data on environmental parameters(moisture), soil characteristics (including N, P, K levels), plant diseases, and consistent crop monitoring, the system recommends the most suitable crop for each season. Moreover, it offers fertilizer suggestions aligned with optimal nutrient requirements, particularly focusing on N, P, and K levels, aiming to enhance farming efficiency and sustainability.

Keywords – NPK levels, plant disease detection, Crop and fertilizer recommendation system.

1. INTRODUCTION

A considerable portion of India's people receives their livelihoods from the agricultural sector, which also significantly contributes to the country's economic growth. However, farmers face a complex challenge in determining the optimal crop for cultivation in a given context.

This complexity arises from the diverse soil characteristics, variable environmental conditions, prevalent plant diseases, and the need for ongoing crop monitoring. To navigate this intricate landscape, this paper presents a comprehensive and technologically advanced approach to support decision-making in agriculture.

Our proposed approach encompasses the use of a diverse range of advanced machine learning models, including Random Forest model, Support Vector Regression (SVR) or Support Vector Classification (SVC) based on the accuracy value , XGBoost, and Decision Tree

techniques. Through rigorous evaluation and comparison of these models, we aim to identify the optimal model for precise crop detection. Our objective is to enhance accuracy and efficiency in determining the most suitable crop for cultivation.

In the domain of plant disease detection, we harness the powerful capabilities of the ResNet model, a deep learning architecture. Implementing this model enables us to accurately and swiftly detect and diagnose plant diseases. This technology facilitates timely disease detection, empowering farmers to take proactive measures to manage and mitigate disease outbreaks, thereby safeguarding their crops.

Furthermore, we envisage integrating IoT technology to conduct real-time soil tests and monitor critical soil characteristics, including nutrient levels and moisture content. This technological advancement enhances our understanding of soil health and facilitates precise fertilizer recommendations tailored to the specific nutrient requirements of the soil. In the future, we plan to expand this initiative to encompass real-time monitoring of soil attributes through IoT, presenting an innovative and sustainable approach to farming practices.

This comprehensive approach aims to revolutionize agricultural practices by combining advanced machine learning techniques, leveraging deep learning capabilities, and integrating IoT technology. Through innovative and technology-driven solutions, we hope to provide farmers with invaluable insights, promote sustainable and efficient farming practices, and contribute to the advancement of India's agricultural sector.

II. LITERATURE SURVEY

[1] Machine learning is used in this integrated agricultural system to provide crop recommendations based on historical planting data and soil nutrient analysis. It takes into account soil type and current weather conditions to recommend optimal crops and nutrient adjustments. A smart irrigation system, which makes use of IoT technology and machine learning, also monitors soil moisture levels. It assesses plant health in real time using computer vision and determines whether irrigation is required. The system also checks the likelihood of rain in the next 24 hours, saving water and avoiding over-irrigation. The Weather Underground applet collects weather data and sends SMS alerts to users to help them make informed irrigation decisions, ultimately promoting efficient crop cultivation and resource conservation.

[2] By predicting crop suitability, this comprehensive agricultural system assists farmers in making informed decisions. It improves accuracy by combining live data with historical temperature, humidity, and rainfall data from government websites. The project combines real-time field data from a DHT-22 sensor with soil type and historical weather data from government or Google Weather API sources. On this dataset, supervised and unsupervised machine learning algorithms are trained, and their accuracy is compared to deliver the most precise crop recommendations and fertilizer suggestions to the end user via a responsive multilingual website. The DHT22 sensor, known for its precision in monitoring temperature and humidity, and the Arduino Uno for data processing are among the hardware components.

[3] By combining real-time and historical data, this system assists farmers in making informed crop decisions. It gathers data on temperature, humidity, and rainfall from government websites, as well as real-time field data from a DHT22 sensor and user-entered soil type. The system forecasts weather conditions and crop suitability using both supervised and unsupervised machine learning algorithms. The accuracy of Decision Tree, K-NN, and Support Vector Machine models is compared in order to provide the best crop recommendation. A responsive, multilingual website makes farmer interaction easier. Furthermore, the system provides fertilizer recommendations based on the crop selected. It collects and analyses data using IoT devices and cloud platforms, ensuring precise crop cultivation guidance.

[4] The system incorporates various sensors, such as the DHT11 for temperature and humidity, the MQ2 for gas and smoke, the Soil Moisture Sensor, and the Light Intensity Sensor, all of which are placed in the field to provide real-time data to a cloud server. This data is then processed and made available to users via a website. Based on real-time sensor readings, the system determines the best crop for the field using the K-Nearest Neighbors (KNN) machine

learning algorithm. Prediction is aided by a standardized dataset of crop requirements. For user convenience, real-time data is plotted, and a Virtualization Page visualizes the data over time. Additionally, email notifications are sent to users to keep them up to date on crop conditions.

[9] To improve farming procedures, the proposed smart agriculture system renders use of IoT and cloud computing. It collects real-time field data employing sensors such as pH and moisture sensors, which is processed by an ATMEGA328 microcontroller and transmitted to a cloud server via an ESP8266 Wi-Fi module. Based on a pre-defined database, a user-friendly mobile app then provides farmers with valuable insights like soil pH, moisture levels, and crop recommendations. This system enhances crop yield, decreases fertilizer costs, and eliminates the need for manual soil testing. It promotes efficient farming practices, utilization of resources, and agricultural sustainability by enabling data-driven decisions in order to meet the challenges of a growing population and climate change.

[16] The proposed method uses a sensor network to estimate soil nutrients efficiently, assisting in the prediction of the best crop for the tested soil. Farmers connect their NPK sensors to a centralized server. These sensors gather nutrient data from soil samples and send it to a server via a Raspberry Pi. An algorithm (detailed in the following section) makes predictions based on sensor data and historical information. When the analysis is finished, a message with the recommended crop is sent to the registered farmer, allowing for more informed crop selection decisions. By providing personalized crop recommendations based on real-time soil data, this system improves farming practices.

III. METHODOLOGY

1. Data Collection:

Initially, we collect a variety of environmental data such as temperature and rainfall, as well as soil parameters such as nitrogen levels and pH. At the same time, we collect data on plant diseases and crop performance. This diverse data is then combined into a uniform database, laying the groundwork for later deep research.

2. Data Preprocessing:

To prepare the collected crop images for training, essential preprocessing steps were carried out. This included standardizing image dimensions, optimizing lighting and contrast, and augmenting the dataset through rotations and scaling. These steps were crucial in enabling the model to effectively identify soil characteristics and make accurate predictions. Additionally, the fertilizer dataset underwent various processing steps to enhance accuracy in fertilizer detection.

3. Machine Learning Model Evaluation and Selection:

Examine and evaluate a variety of machine learning models like Random Forest, XGBoost, and Decision Tree to efficiently detect and suggest crops. Use cross-validation and appropriate measures such as accuracy, recall (sensitivity), specificity, F1 score and Confusion matrix.

4. Deep Learning Model for Plant Disease Detection:

Gather a large dataset of plant images, including both healthy and ill plants. Using the photos, train a deep learning network, especially ResNet, to accurately identify and diagnose plant illnesses. To improve both performance and efficiency, fine-tune the model.

5. IoT Integration for Soil Monitoring

Implement an IoT soil monitoring system with pH, moisture, and temperature sensors. Integrate these into a framework for collecting real-time data and securely transmitting it to a cloud platform. Integrate the system with a farmer database. Continuously monitor crops for changes and immediately notify farmers of important changes in crop attributes for timely intervention and optimal output.

6. Predictive Analytics:

Using integrated environmental, soil, and disease data, use machine learning models to identify acceptable crops for the future crop cycle. Improve agricultural productivity and resource utilization by considering optimal timings for irrigation, herbicide, fertilizer, and manure application.

7. Validation and Testing:

Validate the integrated system through rigorous real-world testing, including farmers and agricultural specialists actively to acquire diverse and insightful input. Conduct rigorous testing techniques to assess crop recommendation accuracy and efficiency, disease detection, and overall operational efficacy. Use their comments to make essential improvements, assuring the system's dependability and usefulness in real-world agricultural circumstances.

IV. CONCLUSION

In conclusion, the development of an intelligent crop selection and agricultural decision support system is a complex and multifaceted process. The objective is to provide farmers with accurate insights for informed decision-making, from data collection and preprocessing through the integration of sophisticated technologies such as IoT and machine learning. The effectiveness of the system is proven by real-world testing, which includes feedback from farmers and agricultural professionals. This iterative technique enables continual development, maintaining the system's accuracy, efficiency, and relevance in answering contemporary agriculture's developing demands. Finally, the incorporation of cutting-edge technology holds immense potential for revolutionizing agriculture, increasing crop output, optimizing resource utilization, and encouraging sustainable agricultural practices.

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