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Data-Driven Smart Farming and Personalized Diet Advisory System

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ABSTRACT: Smart agriculture systems leverage machine learning techniques to enhance crop productivity and resource efficiency. This system integrates sensor data such as soil moisture, temperature, humidity, and nutrient levels to monitor real-time field conditions. Machine learning models analyze historical and real-time data to predict crop yield, detect plant diseases, and recommend optimal irrigation and fertilization schedules. By automating decision-making, the system minimizes water usage, reduces fertilizer waste, and improves overall farm management.

Weather forecasting data is also incorporated to support proactive farming decisions and reduce climate-related risks. The proposed approach enables early detection of crop stress and pest infestation, allowing timely intervention. In addition, the system includes an image-based analysis module where farmers can upload images of fruits or vegetables to identify the produce and estimate its nutritional values such as vitamins, minerals, and caloric content using computer vision and deep learning techniques.

Furthermore, the system personalizes nutritional recommendations based on the user's health conditions, including diabetes, obesity, or nutrient deficiencies. By linking dietary advice to specific health needs and the quantity of produce consumed, it supports better health management alongside sustainable farming. Farmers and consumers receive actionable insights through a user-friendly interface, supporting both production and post-harvest decision-making.

This intelligent system promotes sustainable farming practices, enhances food quality awareness, improves health outcomes, and increases overall profitability. Overall, the machine learning-based smart agriculture system provides a comprehensive and reliable solution to address modern agricultural and dietary challenges.

I. INTRODUCTION

Modern wireless communication and data analytics are revolutionizing traditional farming. Smart agriculture leverages sensors and machine learning to optimize resource efficiency and minimize environmental impact. While existing methods like Support Vector Machines (SVM) often require heavy manual feature engineering and struggle with large image datasets, deep learning models offer more robust disease classification. This project proposes a comprehensive platform that handles the entire lifecycle from soil monitoring to post-harvest nutritional advice.

II. METHODOLOGY

A. Data Collection and Pre-processing

The system processes two main types of data: real-time sensor values and image datasets of fruits and vegetables. Pre-processing steps include:

- **Handling Missing Values:** Ensuring no null entries exist in the sensor dataset.
- **Label Encoding:** Converting categorical plant disease types into numerical values for model training.
- **Image Processing:** Resizing and converting images to grayscale to enhance feature extraction efficiency.

B. Feature Extraction and Classification

Feature extraction utilizes statistical methods and Gray Level Co-occurrence Matrix (GLCM) for texture analysis. The system employs several algorithms for comparative analysis:

- **Random Forest:** Used for its high accuracy in tabular data classification.
- **VGG-19 and ResNet-50:** Deep learning architectures used for leaf disease and produce identification.

III. HARDWARE AND SOFTWARE REQUIREMENTS

The system is implemented using the following specifications:

- **Hardware:** Pentium IV 2.4 GHz, 4GB RAM, and 200GB Hard Disk.
- **Software:** Windows 10 OS, Python language, Flask Framework for the web interface, and Anaconda Spyder IDE.

IV. RESULTS AND DISCUSSION

The performance of various machine learning models was evaluated for accuracy in predictive tasks. Based on the experimental results:

- **Random Forest** achieved the highest accuracy score of **86%**.
- **XGBoost** followed with an accuracy of **84.15%**.
- **Decision Tree** yielded an accuracy of **81.82%**.
- **Linear Regression** resulted in **79.05%**.

These results indicate that ensemble methods like Random Forest are highly effective for the complex variables found in smart farming datasets. Additionally, the pre-processing module successfully handled 16 data columns, including soil pH and nitrogen levels, with zero missing values, ensuring a clean input for the classification models.

V. CONCLUSION

The "Data-Driven Smart Farming and Personalized Diet Advisory System" effectively bridges the gap between agricultural technology and consumer health. By integrating IoT monitoring with advanced deep learning, the system provides a reliable solution for modern agricultural challenges. Future work will focus on optimizing model stability and expanding the nutritional database for a wider variety of global produce.

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