A Novel Crop Prediction and Fertilizer Recommendation System Using Python

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***Abstract*— Agriculture is a critical sector that relies heavily on optimal decision-making for crop selection and fertilizer application. Traditional farming methods often lead to inefficiencies due to a lack of precise, data-driven recommendations. This project, "A Novel Crop Prediction and Fertilizer Recommendation System Using Python," aims to assist farmers in selecting the most suitable crop based on soil nutrients and recommending appropriate fertilizers for enhanced yield. The system leverages Flask, a Python web framework, to build an interactive web-based platform where users can input soil parameters such as Nitrogen (N), Phosphorus (P), and Potassium (K), along with the intended crop. Based on this data, the system predicts the best-performing crops and suggests the most appropriate fertilizers using predefined criteria. The system uses data-driven logic to classify crops as top gainers or top losers and recommends fertilizer types based on nutrient levels. The project consists of a user-friendly web interface developed using HTML, CSS, and JavaScript, integrated with Python for backend processing. The Flask-based API processes user inputs and dynamically generates recommendations. The model ensures that farmers receive accurate and efficient suggestions, thus enhancing productivity, reducing soil degradation, and promoting sustainable farming practices. By implementing this system, we aim to empower farmers with data-backed agricultural insights, ultimately improving decision-making and optimizing fertilizer use for better crop yields.**

***Keywords*—Crop Prediction, Data-Driven Agriculture, Fertilizer Recommendation, Flask, Precision Agriculture Soil Nutrients, Python, , Sustainable Farming, Web Application.**

Introduction

Agriculture is a cornerstone of the global economy and is pivotal for ensuring food security. However, modern farmers face multifaceted challenges, including unpredictable weather patterns, soil degradation, and limited access to precise, data-driven insights. Traditional farming practices, often based on personal experience and generalized guidelines, may not suffice in optimizing crop yields and resource utilization.

Recent advancements in technology offer promising solutions. Integrating machine learning and data analytics into agriculture can revolutionize decision-making processes. For instance, Iniyan et al. [1] developed a machine learning-based crop and fertilizer recommendation system that enhances decision-making by analyzing soil and environmental parameters. Similarly, Musanase et al. [2] proposed a data-driven approach that leverages machine learning to provide precise crop and fertilizer recommendations, thereby improving farming practices. Moreover, the integration of Internet of Things (IoT) devices and remote sensing technologies has further enhanced the precision of agricultural recommendations. Nehra et al. [3] demonstrated the effectiveness of combining IoT and machine learning for fertilizer and crop recommendations, leading to more sustainable agricultural practices. Additionally, Banerjee et al. [4] introduced the concept of digital twins in agriculture, enabling real-time monitoring and simulation of crop growth, which aids in making informed decisions regarding crop and fertilizer selection.

This project aims to bridge existing gaps by developing a web-based application that analyzes soil conditions and environmental factors to recommend optimal crops and fertilizers. By considering essential soil parameters such as nitrogen, phosphorus, potassium levels, temperature, humidity, and rainfall, the system provides scientifically grounded recommendations. The integration of Python (Flask for backend), HTML, CSS, and JavaScript ensures an efficient, scalable, and user-friendly platform.

Literature Survey

A literature survey is essential for understanding existing research, methodologies, and technologies related to crop prediction and fertilizer recommendation systems. This section reviews relevant studies, technologies, and machine learning models employed in modern agriculture.

A. Traditional Approaches to Crop Selection

Historically, crop selection was based on farmers' experience and historical data regarding seasonal cycles and soil fertility. Recommendations from agricultural agencies were often too generalized, offering limited personalization for specific farm conditions. Soil testing was conducted manually, which proved both time-consuming and costly, thereby limiting widespread use among small-scale farmers [5].

B. Machine Learning in Agriculture

Recent advancements in machine learning (ML) and artificial intelligence (AI) have transformed agriculture by providing more accurate and scalable decision-making tools. Decision Trees & Random Forests These algorithms have been effectively used for classifying soil types and predicting optimal crops based on nutrient concentrations. Studies indicate that Random Forests outperform traditional decision-making systems in terms of predictive accuracy [6]. Support Vector Machines (SVM) SVMs have been utilized for yield prediction by analysing soil and historical weather data. Their robustness in handling nonlinear relationships helps achieve high classification accuracy in crop modelling [6]. Artificial Neural Networks (ANNs) ANNs are widely applied in nutrient deficiency prediction and fertilizer recommendation. Their capability to learn complex patterns from large datasets makes them suitable for agriculture-based inference systems [7]. Deep Learning & IoT Integration Integration of IoT sensors and deep learning has enabled real-time monitoring of soil and climate conditions. This approach significantly enhances precision farming, enabling automated large-scale farming decisions [8 – 10].

C. Fertilizer Recommendation Systems

Earlier systems relied heavily on manual interpretation of soil test results. However, recent work has leveraged ML algorithms to predict nutrient levels and recommend fertilizer types in optimized quantities. K-Nearest Neighbours (KNN) algorithms have demonstrated high accuracy in soil fertility classification and are increasingly adopted for automated fertilizer recommendations [5][11 – 12]. Deep Learning Models offer powerful tools for predicting complex soil nutrient interactions and suggesting appropriate fertilizers, reducing environmental harm and cost [7][13 – 15]. Data-Driven Recommendations using large-scale agricultural datasets have been proposed to time fertilizer applications for optimal crop yield, promoting resource-efficient agriculture [10].

D. Limitations of Existing Studies

Despite their effectiveness, existing systems have notable limitations. Many lack real-time integration with weather APIs and sensors. Regional climatic and environmental variations are often not considered. High computational demands make them unsuitable for small-scale farmers. Several platforms lack user-friendly interfaces, reducing accessibility. These limitations highlight the need for holistic and accessible systems that integrate real-time data, are region-aware, and require minimal computational resources [16].

E. Contribution of This Project

This project proposes a solution that addresses these limitations. Using real-time soil parameter inputs (Nitrogen, Phosphorus, Potassium) for accurate crop and fertilizer recommendations. Developing a user-friendly web interface tailored for farmer usability. Applying efficient machine learning models to improve prediction accuracy. Integrating local climate and real-time weather data to enhance the relevance of recommendations. This system contributes significantly to the field of precision agriculture by empowering farmers to make informed, data-driven decisions and improve productivity sustainably.

This feasibility study demonstrates that the proposed Crop Prediction and Fertilizer Recommendation System is not only technically feasible, utilizing cutting-edge machine learning algorithms and cloud-based platforms, but also economically viable due to its reliance on open-source tools and minimal hardware requirements. The system ensures operational sustainability by providing a user-friendly interface that enables farmers with limited technical skills to make data-driven decisions in real-time. Additionally, the system is compliant with legal and environmental standards, promoting sustainable agricultural practices by recommending optimal fertilizer use and adhering to data protection regulations such as the General Data Protection Regulation (GDPR). The functional requirements of the system, such as user input handling, real-time machine learning predictions, and intuitive result display, ensure that it effectively meets the needs of farmers, improving productivity while reducing resource waste. The non-functional requirements, including performance optimization, security, and scalability, guarantee that the system will perform consistently and reliably under varying conditions, catering to both small-scale and large-scale agricultural needs.

To further illustrate how the system operates, a Data Flow Diagram (DFD) provides a clear visual representation of how data flows within the system. It highlights the progression of data from the input (user-provided soil parameters and environmental factors) to the output (crop recommendations and fertilizer suggestions). The DFD maps out the interactions between the various components of the system, including data collection, model execution, and result generation. This step-by-step flow ensures that all components are interconnected and that the system's predictions are based on accurate, real-time data, thus ensuring that the Crop Recommendation System delivers scientifically backed advice that helps farmers optimize their agricultural practices. From data input to the final output of recommendations, the system guarantees a smooth and efficient process, enhancing the decision-making capacity of farmers while promoting sustainable agricultural development.

System Analysis

The proposed crop prediction and fertilizer recommendation system is both technically and economically feasible, making it a practical solution for modern precision agriculture. Developed using Python, the system incorporates machine learning algorithms such as Random Forest, Decision Trees, and Logistic Regression to analyze soil nutrient levels and environmental parameters for accurate recommendations. The web interface, built with the Flask framework, ensures seamless user interaction, while cloud-based deployment on platforms like Firebase or AWS enhances accessibility and scalability. Economically, the use of open-source tools and local computing environments minimizes development and operational costs, making the system affordable for small-scale farmers. Operationally, the system is user-friendly and intuitive, requiring minimal training, and it provides real-time crop and fertilizer suggestions to optimize agricultural output and resource usage. Legally and environmentally, the system promotes sustainable farming practices, adheres to government guidelines, and ensures user data privacy through compliance with standards such as the General Data Protection Regulation (GDPR). Functionally, it supports input handling, machine learning execution, intelligent fertilizer recommendations, result display, data storage, and user interaction via a simple web-based platform. Non-functional requirements are also addressed, with the system designed for high performance, scalability, usability, reliability, data security, and ease of maintenance. Overall, this system provides a cost-effective, reliable, and sustainable solution for data-driven decision-making in agriculture.

A. Hardware Requirements

The hardware requirements for the Crop Prediction and Fertilizer Recommendation System ensure smooth performance and efficiency during both development and deployment stages. For the minimum requirements, the system can operate with a Processor such as an Intel i5 (or its equivalent in other brands), along with 8GB of RAM and a 50GB HDD for storage. These specifications are suitable for basic functionalities and small-scale data processing, making the system accessible to users with entry-level hardware setups. However, for optimal performance, especially when handling larger datasets, performing more complex machine learning tasks, or scaling the system for multiple users, it is recommended to use a more powerful processor, such as an Intel Core i7/i9 or an AMD Ryzen 7+, paired with at least 16GB of RAM. Additionally, a 256GB SSD storage option is preferred, as it offers significantly faster data read and write speeds compared to traditional HDDs, which improves the overall system performance and reduces latency. While the system can function without a dedicated GPU, NVIDIA or AMD GPUs are highly recommended, particularly for machine learning training. These dedicated graphics processors speed up data processing and training of machine learning models, enhancing the efficiency of the system and allowing for faster insights generation. Overall, while the minimum requirements ensure basic functionality, the recommended configuration optimizes system performance, scalability, and machine learning capabilities, ensuring that the system runs smoothly under various operational conditions.

B. Software Requirements

The proposed Crop Prediction and Fertilizer Recommendation System is built using a combination of modern technologies and tools that ensure efficiency, scalability, and ease of use. The programming language used for development is Python, renowned for its simplicity, versatility, and the rich ecosystem of libraries that make it ideal for data science and machine learning applications. For the backend, the Flask framework is utilized, chosen for its lightweight and flexible nature, which allows for easy integration of machine learning models and user requests. For the frontend, Bootstrap is employed, providing a responsive and visually appealing interface that enhances user experience across devices. The core of the system relies on powerful machine learning libraries such as Scikit-Learn and TensorFlow for predictive modeling and classification tasks, while Pandas and NumPy handle data manipulation, preprocessing, and analysis. The system's data storage needs are managed using versatile databases such as SQLite, which is well-suited for smaller datasets, and Firebase and MongoDB, which provide scalable cloud-based solutions to store large, complex datasets that the system processes. In terms of deployment, the system is designed to be hosted on cloud platforms like AWS (Amazon Web Services), Heroku, or Google Cloud, ensuring high availability, scalability, and robust performance while also offering the flexibility to scale as user demand increases. This infrastructure enables the system to provide seamless access and real-time predictions to farmers, enhancing their decision-making capabilities in the field.

C. Network & Deployment Requirements

The Network and Deployment Requirements for the proposed Crop Prediction and Fertilizer Recommendation System are designed to ensure efficient operation, real-time data processing, and seamless integration with modern agricultural technologies. First and foremost, a high-speed internet connection is essential for cloud-based operations, including model training and real-time data transfer. The cloud infrastructure enables large-scale data processing, ensuring that soil and environmental data can be rapidly analyzed and predictions can be delivered almost instantaneously to the users. To address potential connectivity issues in remote farming areas, edge computing capabilities are incorporated into the system. This allows for local processing of critical data, such as video feeds or sensor readings, without the need for constant cloud interaction, thus reducing latency and dependence on stable internet connections. Furthermore, the integration of autonomous vehicles—such as drones or robots—can enhance the system's capabilities, offering real-time monitoring and data collection directly from the field. This optional feature can be integrated through the Robot Operating System (ROS), which facilitates communication and control of robotic platforms. These vehicles can be deployed for automated tasks like soil sampling, crop health monitoring, and fertilizer application, which further optimize farming practices by ensuring that the correct recommendations are applied at the right time and location. Together, these requirements ensure that the system is both robust and adaptable, capable of operating in diverse agricultural environments and enhancing precision farming techniques.

D. Data flow diagram

A Data Flow Diagram (DFD) is a graphical representation that illustrates the flow of data within a system, detailing how data moves from input to output through various processes. This diagram is essential for understanding the interaction between different components of the system and how they work together to achieve the desired outcome. In the context of the Crop Recommendation System, the DFD provides a step-by-step view of how data flows from the user input to the system's output, highlighting the relationships between each entity and process. Initially, the user inputs soil data, which includes key nutrient levels such as Nitrogen (N), Phosphorus (P), and Potassium (K), along with any relevant environmental factors (e.g., temperature, rainfall, humidity) that might impact crop growth. This input data is then sent to the system for processing, where it undergoes a series of steps. First, the system fetches crop data from its database, which includes information about various crops, their ideal growth conditions, and their nutrient requirements. The system then uses an advanced Machine Learning (ML) model to analyze the soil properties and compare them with the ideal conditions needed for different crops. Based on this analysis, the model predicts the most suitable crop for the given conditions. After the data has been processed, the system outputs the recommended crop to the user, providing them with a list of the most viable options. Additionally, it provides insights by displaying top gainers and losers, which helps farmers understand the potential of various crops under the given soil conditions. Finally, the system fetches fertilizer data from the database, offering suggestions on the right fertilizers to optimize soil health and boost crop growth. This flow ensures that the system delivers accurate, actionable, and data-driven insights, helping farmers make informed decisions to improve productivity and sustainability.

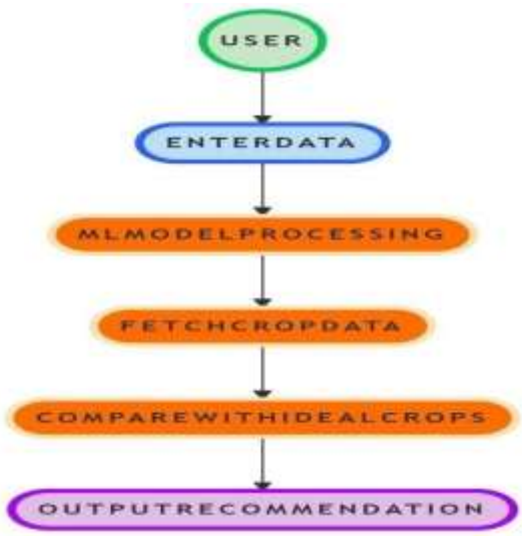

Figure 1. Data Flow Diagram

Results and Discussion

1) *Screen-1:*

Figure 2. Empowering farmers with precision agriculture solution

2) *Screen-2:*

Figure 3. Recommendations

3) Screen-3

Figure 4. Recommended crop

4) Screen-4:

Figure 5. Crop Growing Conditions

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5) Screen-5:

Figure 6. Fertilizer

6) Screen-6:

Figure 7. Recommended Fertilizer

Testing

Testing is a crucial phase in the Software Development Life Cycle (SDLC), ensuring that the system functions correctly, meets user requirements, and is free from defects. The primary objective of testing is to identify and resolve bugs, verify system functionality, and validate that the software performs as expected under various conditions. In this project, testing plays a vital role in ensuring the accuracy and efficiency of vehicle detection, counting, and real-time tracking. It also ensures that the system provides reliable responses, handles errors properly, and performs at an acceptable level of speed and reliability.

Testing is performed using several methodologies to cover all aspects of the system's functionality:

- **Unit Testing:** This involves testing individual components or functions of the system in isolation to ensure they perform as expected. It verifies that each function operates correctly in the smallest possible unit of the software.
- **Integration Testing:** This stage ensures that different modules of the system, such as the input processing module, vehicle detection algorithm, and tracking functionality, work together correctly when integrated.
- **System Testing:** This step involves validating the complete system against the defined requirements. It ensures that the system as a whole functions as expected and meets the needs of the users in terms of features and performance.
- **Performance Testing:** Performance testing evaluates the system's speed, responsiveness, and overall performance under varying load conditions, ensuring that it can handle real-time data processing efficiently, such as processing video inputs and performing vehicle detection within acceptable time limits.
- **User Acceptance Testing (UAT):** This stage ensures that the system meets the expectations of end users, focusing on whether the system delivers its intended value and functionality from a user perspective.

For this specific project, the testing process focuses on several critical components: video input processing, vehicle detection accuracy, real-time tracking efficiency, and error handling. By performing these tests, we ensure that the system functions as expected in both typical and edge-case scenarios, providing reliable results to the end users.

Sample Test Cases

Below are some sample test cases for validating the chatbot functionality and ensuring all features perform correctly:

Test Case 1: Greeting Message

- Test ID: TC001
- Description: Verify that the chatbot responds correctly to a greeting message.
- Input: "Hello"
- Expected Output: "Hi there" or "Hello" or any other appropriate greeting response.
- Actual Output: (To be filled after testing)
- Status: Pass/Fail

Test Case 2: Exam Schedule Query

- Test ID: TC002
- Description: Check if the chatbot provides the correct exam schedule details.
- Input: "When are the semester exams?"
- Expected Output: "The semester exams start from 10th May 2025. Check the official website or notice board for updated exam timetables."
- Actual Output: (To be filled after testing)
- Status: Pass/Fail

Test Case 3: Thanks Response

- Test ID: TC003
- Description: Verify that the chatbot responds correctly to a thank-you message.
- Input: "Thank you"
- Expected Output: "You're welcome" or "No problem"
- Actual Output: (To be filled after testing)
- Status: Pass/Fail

Test Case 4: Unrecognized Input Handling

- Test ID: TC004
- Description: Ensure the chatbot provides a fallback response for unrecognized inputs.
- Input: "Tell me a joke"
- Expected Output: "Sorry, I don't understand that." (or any default response)
- Actual Output: (To be filled after testing)
- Status: Pass/Fail

Test Case 5: Voice Input Recognition

- Test ID: TC005

- Description: Verify that the chatbot can process voice input correctly.
- Input: User speaks "Hello" using a microphone.
- Expected Output: "Hi there" or "Hello"
- Actual Output: (To be filled after testing)
- Status: Pass/Fail

Test Case 6: Voice Output Functionality

- Test ID: TC006
- Description: Check if the chatbot correctly converts text responses into speech.
- Input: "Hello"
- Expected Output: Chatbot speaks "Hi there."
- Actual Output: (To be filled after testing)
- Status: Pass/Fail

Test Case 7: Exit Command

- Test ID: TC007
- Description: Ensure the chatbot exits when the user says "Goodbye."
- Input: "Goodbye"
- Expected Output: "Thank you for chatting with me. Have a great day!" and chatbot stops execution.
- Actual Output: (To be filled after testing)
- Status: Pass/Fail

These test cases are designed to cover a wide range of potential interactions, ensuring that the chatbot handles common queries, unexpected inputs, and voice-based interactions with reliability. By conducting these tests, the system will be refined and validated, ensuring a smooth user experience and efficient functionality across all features.

Conclusions

In conclusion, the Crop Prediction and Fertilizer Recommendation System represents a significant leap forward in the integration of Machine Learning (ML) and Data Science into agriculture. By leveraging real-time data on soil health, weather conditions, and nutrient levels, the system provides precise, data-driven insights that help farmers make informed decisions about crop selection and fertilizer application. This reduces the reliance on traditional, trial-and-error methods, optimizing agricultural productivity while promoting sustainable farming practices. The system's ability to recommend the right crops and fertilizers, based on individual farm conditions, ensures that farmers can improve their yields and resource efficiency, thereby enhancing profitability. Furthermore, by minimizing the overuse of fertilizers and encouraging responsible farming practices, it contributes to the long-term health of the soil and the environment. The user-friendly design of the system ensures that even those with limited technical knowledge can benefit from its capabilities. Looking ahead, the system holds great potential for further innovation, with future enhancements such as automated irrigation, IoT-based soil monitoring, and AI-powered predictive analytics. These advancements will allow for even more precise and proactive agricultural management, enabling farmers to address challenges such as pest control, climate variability, and resource management more effectively. Ultimately, this system exemplifies how AI and data science can revolutionize agriculture, ensuring that it remains productive, sustainable, and responsive to global food security challenges. Through continuous advancements in technology, the system will play an essential role in achieving a sustainable and prosperous agricultural future for farmers worldwide.

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REFERENCES

[1] Iniyan, S., Raja, M.S., Srinivasan, R., Santhanakrishnan, C. and Srinivasan, A., 2023, December. Crop and Fertilizer Recommendation System Applying Machine Learning Classifiers. In *2023 International Conference on Emerging Research in Computational Science (ICERCS)* (pp. 1-6). IEEE.

[2] Musanase, C., Vodacek, A., Hanyurwimfura, D., Uwitonze, A. and Kabandana, I., 2023. Data-driven analysis and machine learning-based crop and fertilizer recommendation system for revolutionizing farming practices. *Agriculture*, *13*(11), p.2141.

[3] Nehra, V., Anand, A. and Kumari, N., 2023, January. Fertilizer and Crop Recommendation using IoUT and Machine Learning. In *2023 13th International Conference on Cloud Computing, Data Science & Engineering (Confluence)* (pp. 629-634). IEEE.

[4] Banerjee, S., Mukherjee, A. and Kamboj, S., 2025. Precision Agriculture Revolution: Integrating Digital Twins and Advanced Crop Recommendation for Optimal Yield. *arXiv preprint arXiv:2502.04054*.

[5] Manoj, K.D., Malyadri, N., Srikanth, M.S. and Ananda, B.J., 2021. A machine learning model for crop and fertilizer recommendation.

[6] Medar, R., Rajpurohit, V.S. and Shweta, S., 2019, March. Crop yield prediction using machine learning techniques. In *2019 IEEE 5th international conference for convergence in technology (I2CT)* (pp. 1-5). IEEE.

[7] Dash, S.S. and Kumar, P., 2024. Farmers' Toolkit: Deep Learning in Weed Detection and Precision Crop & Fertilizer Recommendations. In *BIO Web of Conferences* (Vol. 82, p. 05012). EDP Sciences.

[8] Prathik, K., Madhuri, J. and Bhanushree, K.J., 2023, November. Deep Learning-Based Fertilizer Recommendation System Using Nutrient Deficiency Prediction. In *2023 7th International Conference on Computation System and Information Technology for Sustainable Solutions (CSITSS)* (pp. 1-6). IEEE.

[9] Banerjee, S., Mukherjee, A. and Kamboj, S., 2025. Precision Agriculture Revolution: Integrating Digital Twins and Advanced Crop Recommendation for Optimal Yield. *arXiv preprint arXiv:2502.04054*.

[10] Ikhlaq, U. and Kechadi, T., 2023. Machine Learning-based Nutrient Application's Timeline Recommendation for Smart Agriculture: A Large-Scale Data Mining Approach. *arXiv preprint arXiv:2310.12052*.

[11] Géron, A., 2022. *Hands-on machine learning with Scikit-Learn, Keras, and TensorFlow: Concepts, tools, and techniques to build intelligent systems*. " O'Reilly Media, Inc.".

[12] Manning, C. and Schutze, H., 1999. *Foundations of statistical natural language processing*. MIT press.

[13] Sandhya, K., Malasri, T. and Rao, E.Y.V., 2024. Voice Guidance For Blind People With Ultrasonic Obstacle Avoidance. *International Journal of Multidisciplinary Research and Explorer*, *4*(3), pp.30-43.

[14] Goldberg, Y., 2016. A primer on neural network models for natural language processing. *Journal of Artificial Intelligence Research*, *57*, pp.345-420.

[15] Ahmed, B., Shabbir, H., Naqvi, S.R. and Peng, L., 2024. Smart Agriculture: Current State, Opportunities and Challenges. *IEEE Access*.

[16] Ramesh, D. and Vardhan, B.V., 2015. Analysis of crop yield prediction using data mining techniques. *International Journal of research in engineering and technology*, *4*(1), pp.47-473.