Precision Agriculture Decision Support Using Machine Learning

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Abstract - The agricultural sector stands as the cornerstone of the Indian economy, with farmers often faced with the critical decision of selecting the most appropriate crop to cultivate based on multifaceted considerations such as profitability, market demand, soil quality, and climatic conditions. The ramifications of making suboptimal decisions can be profound, potentially exacerbating financial strain and even leading to tragic outcomes such as suicides. In light of these challenges, developing a robust system capable of offering predictive insights to Indian farmers regarding crop selection for specific seasons is imperative. To bolster decision-making and optimize resource utilization, this project presents a machine learning-powered agricultural decision support system. It tackles three crucial aspects: recommending the most profitable crop based on market demand, weather data, and soil analysis; suggesting the optimal fertilizer tailored to the chosen crop and environmental conditions; and detecting plant diseases through image analysis. This empowers Indian farmers with data-driven insights for improved crop selection, sustainable fertilizer use, and early disease identification, ultimately fostering agricultural productivity and farm income.

***Key Words*: Precision agriculture, Recommendation system, Random Forest, Crop Recommendation, Fertilizer recommendation, Plant Disease detection, Machine Learning**.

1. INTRODUCTION

The section provides an overview of project goals, history, and applications. It outlines the context, specifications, parameters, and scope.

1.1 PROBLEM STATEMENT

Indian farmers face significant challenges in crop selection, fertilization, and disease management. Traditional methods often rely on intuition and limited data leading to suboptimal outcomes and potential financial losses.

1.2 EXISTING SYSTEM

Despite farmers' experience, unpredictable weather patterns necessitate a shift towards data-driven crop selection. Existing prediction systems, often relying on just three factors, lack accuracy and efficiency. This project proposes a more robust approach using advanced algorithms like Regularized Greedy Forest to analyze multiple parameters and recommend optimal crops, along with potential challenges and solutions.

1.2.1 DISADVANTAGES OF EXISTING SYSTEM

- Improper analysis due to the diversity of seasons and rainfall.
- Less accuracy and crop production.
- Usage of less effective algorithms and factors
- Low performance.

1.3 PROPOSED SYSTEM

This project introduces a machine learning-powered Precision agricultural decision support system (PADSS) for Indian farmers. Unlike the limitations of existing systems, our ADSS offers a comprehensive approach using various machine learning algorithms. It tackles three areas:

1. Crop Recommendation: Recommends the most profitable crop based on market demand, weather data (beyond basic factors), and soil analysis.
2. Fertilizer Recommendation: Suggest the most suitable fertilizer type and application rates considering the chosen crop and environmental conditions.
3. Disease Detection: Enables early detection of plant diseases through image analysis, allowing farmers to take timely action.

This data-driven PADSS empowers Indian farmers with valuable insights for improved crop selection, sustainable fertilizer use, and disease management, ultimately enhancing agricultural productivity and farm income.

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2. SYSTEM ARCHITECTURE

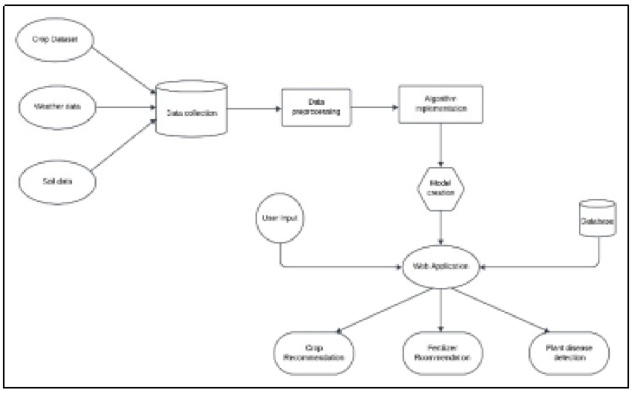

Fig -1: System Architecture

2.1 MODULES DESCRIPTION

The whole project is divided into five modules:

- Collection of Datasets
- Data Pre-Processing
- ML Algorithm model training
- Model Evaluation and Selection
- Model Integration with Web Application

1. Collection of Datasets: We have chosen to leverage datasets from Kaggle. These datasets encompass crucial factors like yield, fertilizer application, soil nutrient content, rainfall patterns, and temperature variations.

2. Data Pre-Processing: For the successful application pre-processing is required. The data which is acquired from different resources are sometimes in raw form. It may contain some incomplete, redundant, inconsistent data. Therefore, in this step, such redundant data should be filtered. Data should be normalized.

3. ML Algorithm model training: This project uses two machine learning algorithms to achieve high accuracy in crop recommendations and plant disease detection:

- Random Forest: This algorithm is used in building a crop recommendation system. It is a Supervised learning technique. It is an ensemble method combining multiple decision trees. It Improves accuracy by averaging predictions from individual trees
- Convolutional Neural Network (CNN): This one is used in the Plant Disease Detection part of the application. It is inspired by the structure of the visual cortex. It is powerful for image recognition tasks like object detection. Therefore, it Extracts features directly from pixel data using convolution and pooling layers. It is Robust to variations in images, making it applicable in diverse fields.

4. Model evaluation and selection: A crucial step is evaluating the performance of each trained model using appropriate metrics (e.g., accuracy, precision, recall). By comparing these metrics, you can select the most efficient model, which is then saved using the Pickle library.

5. Model integration with web application: To facilitate real-time predictions, the chosen model is integrated into a user-friendly web application built with Flask. This web interface will provide a convenient platform for farmers to interact with the system.

2.2 SYSTEM REQUIREMENTS

The following section outlines the requirements needed to implement this idea in practice.

2.2.1 SOFTWARE REQUIREMENTS

The software specifications required to implement the proposed system are shown below:

- Operating System: Windows 10/11
- Coding Language: Python
- IDE: PyCharm
- Front-end: Html, CSS, Javascript
- Back-end: Flask

2.2.2 HARDWARE REQUIREMENTS

The hardware specifications required to implement the proposed system are shown below:

- Processor: Any processor above 500 MHz
- RAM: 4 GB and above
- Hard disk: 4GB and above

2.3 MODELLING

Use-oriented techniques are widely used in software requirement analysis and design. Use cases and usage scenarios facilitate system understanding and provide a common language for communication. This paper presents a scenario-based and flow-oriented modeling technique and discusses its applications.

- Use case diagram: The use case diagram depicts actors (e.g., farmer) interacting with the system (e.g., agricultural decision support system) through functionalities (e.g., crop recommendation, disease detection).

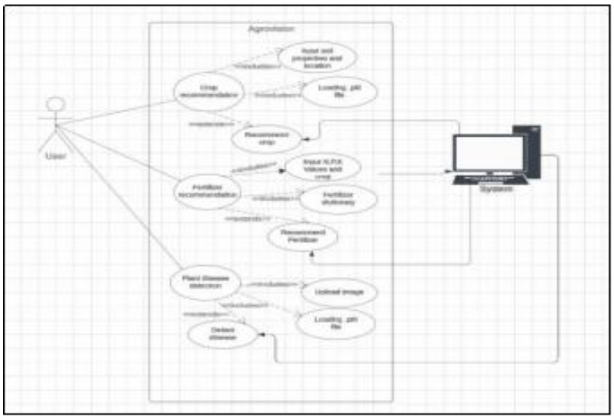

Fig -2:Use case diagram

- Activity diagram: An activity diagram visually represents the flow of activities and actions within a system or process, depicting the sequence of steps and decision points to achieve a desired outcome.

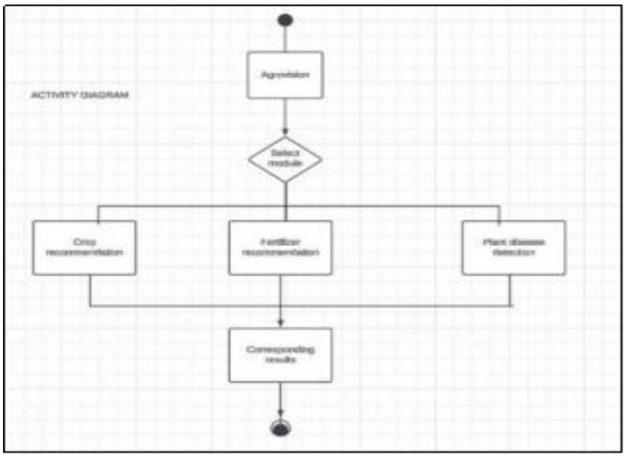

Fig -3: Activity diagram

- State chart diagram: A state chart diagram models the dynamic behavior of a system by representing the various states an object can be in and the transitions between these states in response to events or conditions.

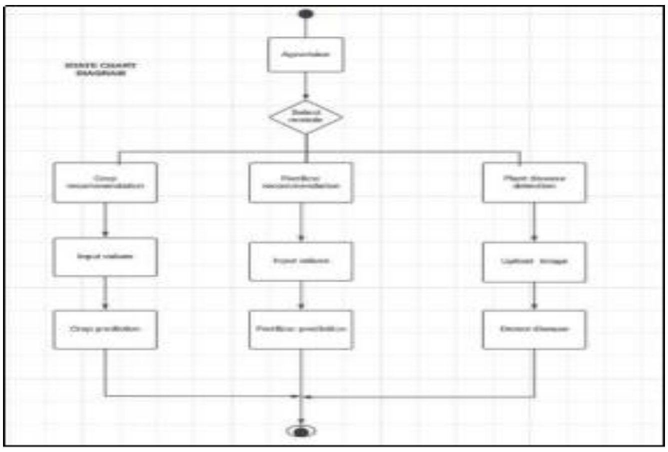

Fig -4: State chart diagram

- Sequence diagram: A sequence diagram illustrates the interactions between objects or components in a system over time, depicting the order of messages exchanged between them to accomplish a specific task or scenario.

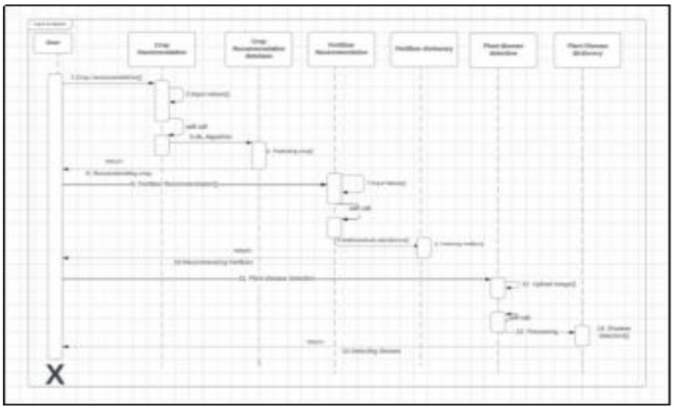

Fig -5: Sequence diagram

- Class diagram:A class diagram provides a structural overview of a system by depicting the classes, their attributes, methods, and relationships, highlighting the static structure of the system.

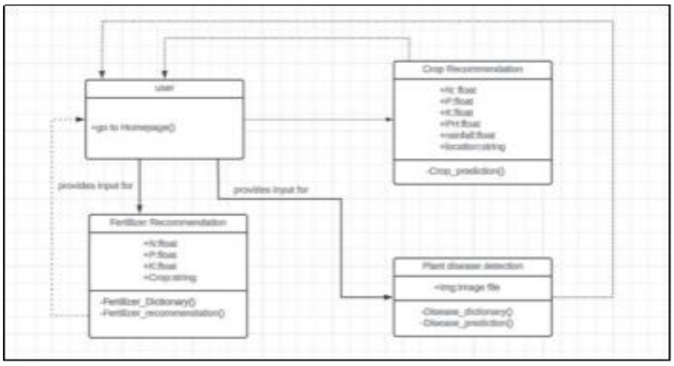

Fig -6: Class diagram

3. IMPLEMENTATION & RESULTS

The datasets from Kaggle were used to test the application's output in real time. The following section displays screenshots of multiple operation results.

A. 3.1 LANDING PAGE

The home module gives an overview of what the overall project is about. This module consists of a frontend design and consists of links to other modules so that we can easily go from one module to another. The home module consists of a crop recommendation module, a fertilizer recommendation module, and a disease detection module. The home module plays an important role as it attracts users to visit the website more and more.

Fig-7: Landing page

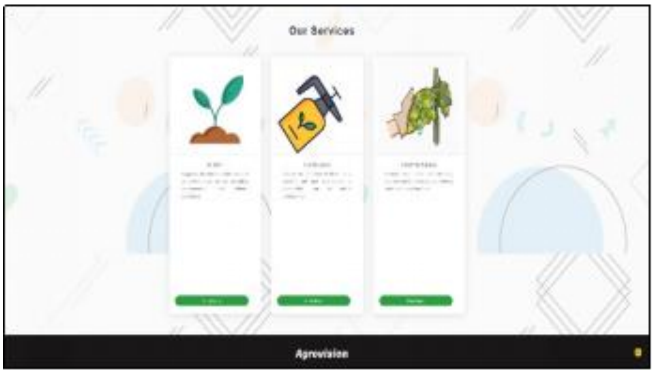

Fig-8: Home page(modules)

3.2 CROP RECOMMENDATION

This module recommends the type of crops to be cultivated which is best suited for the respective conditions. There are several parameters from which we can determine the best crop used like – nitrogen, phosphorous, potassium, pH level, rainfall, and state. The use of cognitive technologies in agriculture could help determine the best crop choice or the best hybrid seed choice for the crop mix adapted to various objectives, and conditions and better suited for farm need. This problem requires the use of several datasets since crop yield depends on many different factors such as climate, weather, soil, use of fertilizer, and seed variety.

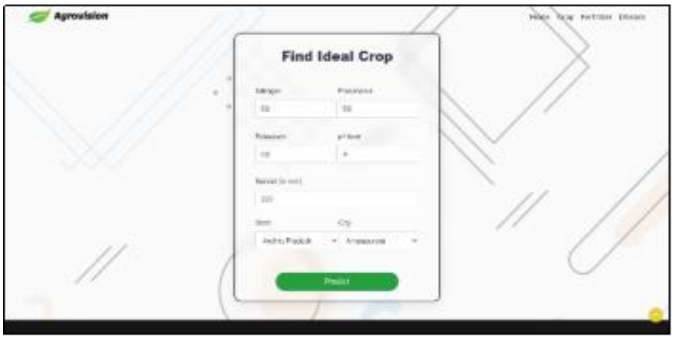

Fig-9: Crop recommendation page

Fig-10: Crop recommendation result

3.3 FERTILIZER RECOMMENDATION

This module recommends which fertilizer is suitable for the crop based on the N, P, and K values. As we know soil is a combination of nitrogen, potassium, and phosphorous. Their proper quantity makes the soil fertile. So, by knowing the exact quantity of these three components the farmer can easily predict which fertilizer will be beneficial for them. This saves a lot of time for farmers and makes their work easy. To determine the fertilizer, we should have data on these three components. Using these data, a machine learning model is created and the model is trained.

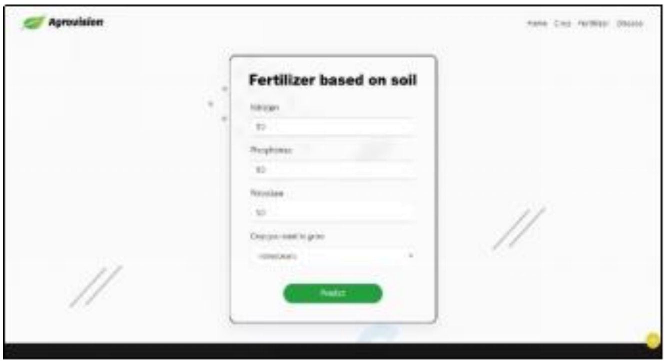

Fig-11: Fertilizer recommendation page

Fig-12: Fertilizer recommendation result

3.4 PLANT DISEASE DETECTION

Crop diseases are a major threat to food security, but their rapid identification remains difficult in many parts of the world due to the lack of necessary infrastructure. This module predicts the names and causes of crop diseases and gives suggestions to cure them. In this, we take data from a dataset where different aspects and solutions will be given to cure the disease which is affected by crops. Most farmers are unable to determine the cause of disease in the crop because of that they may get a huge amount of loss. Machine learning approaches such as SVM, K-NN, and CNN are used to distinguish diseased or non-diseased leaves. The analysis of the proposed model is well suited for the CNN machine learning classification technique with the desired accuracy compared to other state-of-the- art methods.

Fig-13: Plant Disease Detection page

Fig-14: Plant Disease Detection result

4. CONCLUSIONS

In summary, this application greatly helps farmers by providing data-driven insights and automation, this system empowers Indian farmers to make informed decisions regarding crop selection, fertilization, and disease management. This can increase agricultural productivity, improve farm income, and enhance crop resilience against diseases.

5. FUTURE SCOPE

While Agrovision effectively tackles several challenges faced by Indian farmers, there's always room for further refinement and expansion. The current modules focusing on crop recommendation, fertilizer suggestion, and plant disease detection provide a strong foundation. However, the vast and ever-evolving field of agriculture presents exciting opportunities for future development. By continuously incorporating new technologies and addressing emerging agricultural needs, Agrovision has the potential to become an even more comprehensive and impactful tool for Indian farmers.

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