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AI-BASED DECISION SUPPORT FOR CROP FARMING

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Abstract

Agriculture plays a crucial role in ensuring food security and economic sustainability. Farm- ers face challenges such as climate variability, crop diseases, soil nutrient imbalance, and volatile market prices. Traditional decision-making methods often lead to reduced productivity and financial losses.This paper presents AgroVision, an AI-driven intelligent decision support system designed to assist farmers throughout the crop lifecycle. The system integrates Convolutional Neural Networks for crop disease detection, supervised learning models for soil fertility estimation and crop yield prediction, and time-series forecasting models for market price prediction.Unlike IoT-based systems, AgroVision operates without hardware sensors, making it cost- effective and accessible to small and medium-scale farmers.

Keywords: Artificial Intelligence, Crop Disease Detection, Soil Fertility Estimation, Yield Prediction, Market Forecasting, Sustainable Agriculture

1 Introduction

Agriculture remains the fundamental pillar of global food security and economic stability, particularly in developing nations where a significant portion of the population depends on farming for their livelihood. However, the sector is currently facing a "perfect storm" of challenges. Climate change has made weather patterns erratic, while soil degradation and the rapid spread of virulent crop diseases have made traditional farming methods increasingly unreliable. For small and medium-scale farmers, a single undetected pest outbreak or a sudden drop in market prices can result in total financial ruin.

In recent years, "Smart Farming" has been proposed as a solution, but it often comes with a high barrier to entry. Most existing technologies rely heavily on Internet of Things (IoT) sensors, which require constant electricity, internet connectivity, and expensive maintenance. This creates a "digital divide" where only wealthy industrial farms can afford the tools needed to survive. Furthermore, the available software solutions are often fragmented—a farmer might use one app for disease detection and another for price tracking, leading to a confusing and inefficient workflow.

To bridge this gap, this paper introduces **AgroVision**, a unified, AI-driven Intelligent Decision Support System (IDSS). Unlike traditional methods, AgroVision is designed to be a "software-only" ecosystem, removing the need for physical hardware sensors. By combining deep learning for disease identification, ensemble learning for yield prediction, and time-series forecasting for market trends, it provides a comprehensive 360-degree view of the crop lifecycle. Our goal is to democratize precision agriculture, turning a simple smartphone into a powerful tool for sustainable farming and economic resilience.

1.1 Existing System:

Analysis of Agricultural Decision Support Frameworks Current precision agriculture predominantly relies on Internet of Things (IoT) nodes for real-time monitoring of soil and climatic variables. While these systems provide granular data, they impose significant financial burdens on small-scale farmers regarding hardware installation, sensor maintenance, and technical upkeep. Furthermore, most academic research remains fragmented, offering isolated solutions for either disease detection or price prediction, rather than a cohesive, multi-modular decision support framework.

1.2 Proposed System:

To overcome these limitations, AgroVision is proposed as a fully software-based AI-driven decision support system. Unlike hardware-dependent systems, AgroVision integrates multiple intelligent modules including image-based crop disease detection, soil fertility estimation, crop yield prediction, market price forecasting, and crop scheduling guidance within a single plat- form. By eliminating hardware dependency and utilizing machine learning and deep learning models.

the system provides cost-effective, scalable, and accessible technological assistance to farmers. The proposed approach enhances data-driven decision-making and promotes sustain- able agricultural practices.

2 Literature Survey

Recent scholarly advancements have shifted toward deep learning for automated plant pathology. Mohanty et al. pioneered the use of Convolutional Neural Networks (CNNs) to identify visual anomalies in foliage, demonstrating that deep architectures can extract complex textures and lesion patterns far more accurately than manual inspection. These CNN-based systems have become the gold standard for early-stage diagnosis, utilizing visual transformers to significantly reduce the probability of total crop failure in rural settings.[1]

Beyond pathology, the predictive modeling of crop yields has evolved through ensemble learning. Research highlights the efficacy of Random Forest algorithms in managing the non-linear relationships between environmental variables. such as pH levels and rainfall—and agricultural output. Unlike traditional linear models, these ensemble methods account for high variance in soil nutrient data (Nitrogen, Phosphorus, and Potassium), providing a more resilient estimation of harvest volume prior to the growing season.[2][3]

For economic sustainability, time-series forecasting has moved from statistical ARIMA models to Recurrent Neural Networks (RNNs). Specifically, Long Short-Term Memory (LSTM) networks have shown superior performance in capturing the seasonal "memory" of market prices and long-term dependencies. While these individual modules show promise, there is a distinct gap in the literature regarding a unified AI processing layer that bridges soil health, disease tracking, and market forecasting within a single user-centric dashboard. AgroVision is designed to address this fragmentation by synthesizing these disparate domains into a singular decision-support ecosystem. [4][5]

3 Methodology

The AgroVision system follows a structured methodological framework consisting of data collection, preprocessing, model development, training, evaluation, and deployment. The over all methodology is designed to ensure reliability, scalability, and practical applicability in real- world agricultural environments.

3.1 Data Collection

Multiple datasets were utilized for different modules of the system. For crop disease detection, labeled plant leaf image datasets containing healthy and diseased samples were collected from publicly available agricultural repositories.

For soil fertility estimation and crop yield prediction, structured datasets containing soil nutrient values (Nitrogen, Phosphorus, Potassium), pH levels, rainfall, temperature, and historical yield records were used.

Market price forecasting relied on historical crop price data collected across multiple seasons to capture trend variations and seasonal fluctuations.

3.2 Data Preprocessing

Data preprocessing was performed to improve model performance and reliability. Image data underwent resizing, normalization, and noise reduction to maintain uniform input dimensions.

Structured datasets were cleaned by handling missing values, removing inconsistencies, and applying feature scaling where necessary. The datasets were divided into training and testing sets using an 80:20 split to ensure unbiased performance evaluation.

3.3 Model Development

Different machine learning and deep learning models were developed for each module:

- A Convolutional Neural Network (CNN) was designed for crop disease classification.
- Supervised learning algorithms were implemented for soil fertility estimation.
- Regression-based models such as Random Forest were applied for crop yield prediction.
- Time-series learning models were used for market price forecasting.

Each model was selected based on suitability for the nature of the data and prediction objec- tive.

3.4 Model Training and Validation

The models were trained using labeled training datasets. During training, hyperparameters such as learning rate, number of layers, and tree depth were tuned to optimize performance.

Validation was performed using testing datasets to evaluate model generalization capability. Performance metrics such as accuracy, precision, recall, and error rates were calculated to assess reliability.

3.5 System Integration

After individual model validation, all modules were integrated into a unified system archi-tecture. A backend framework was used to connect predictive models with the user interface.

The final system allows users to upload images, input soil parameters, and retrieve predic- tions through a centralized dashboard. This integration ensures smooth interaction between data input, model processing, and result visualization.

3.6 Deployment Framework

The system is designed as a web-based application to ensure accessibility. Farmers can access the platform using standard internet-enabled devices such as smartphones or laptops. The modular architecture allows future scalability, including mobile application deployment and real-time API integration.

4 System Architecture

The architecture follows a layered design:

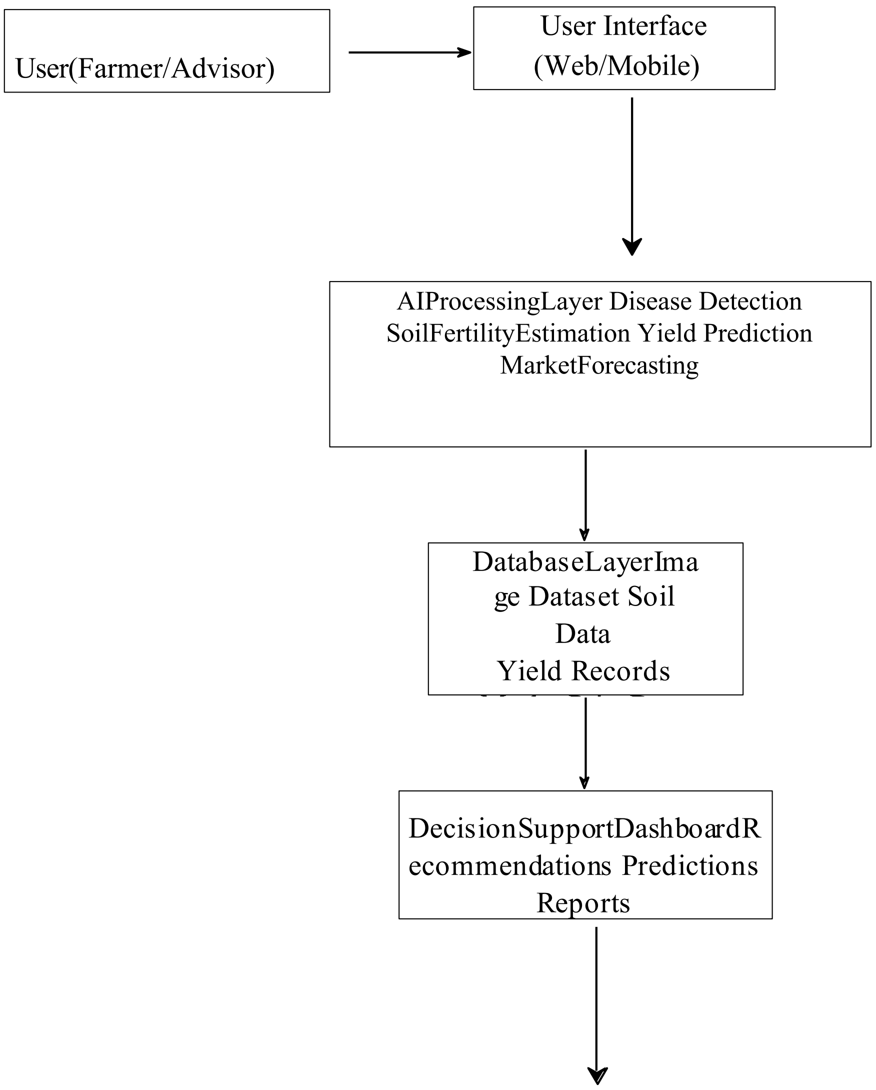


Figure 1: System Architecture of AgroVision

The AI layer contains independent micro-modules for each predictive task. The database stores historical agricultural datasets, disease image datasets, and market price data.

5.Results and Discussion

Table 1: Model Performance Comparison

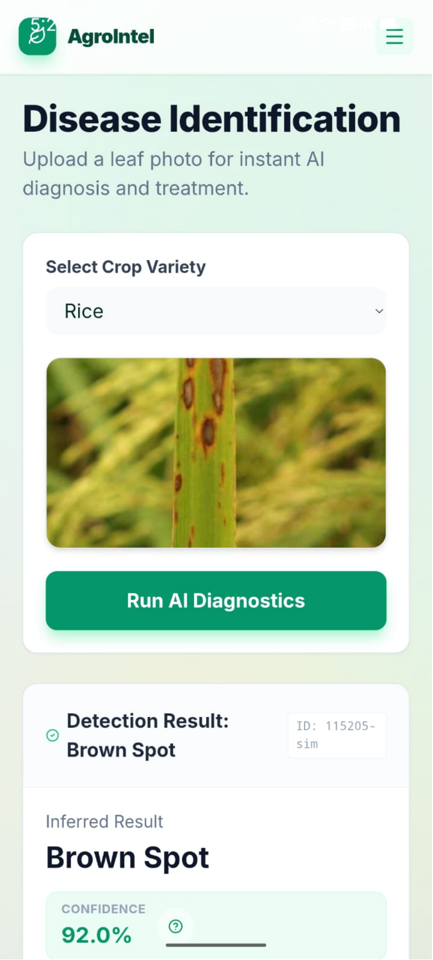
Model	Task	Performance
CNN	Disease Detection	96% Accuracy
Random Forest	Yield Prediction	92% Accuracy

LSTM	Price Forecasting	RMSE = 4.8

Results indicate that deep learning models provide robust disease classification, while en- semble methods improve yield stability. LSTM performs better than ARIMA in volatile price conditions. This section presents the outputs generated by the AgroVision system. The results demon- strate the effectiveness of the implemented AI modules in assisting agricultural decision-making.

5.1 Crop Disease Detection Result

The following screenshot illustrates the image upload interface and the predicted disease classification along with treatment recommendations.



Disease Identification

Upload a leaf photo for instant AI diagnosis and treatment.

Select Crop Variety: Rice

Detection Result: Brown Spot

ID: 115205-sim

Inferred Result

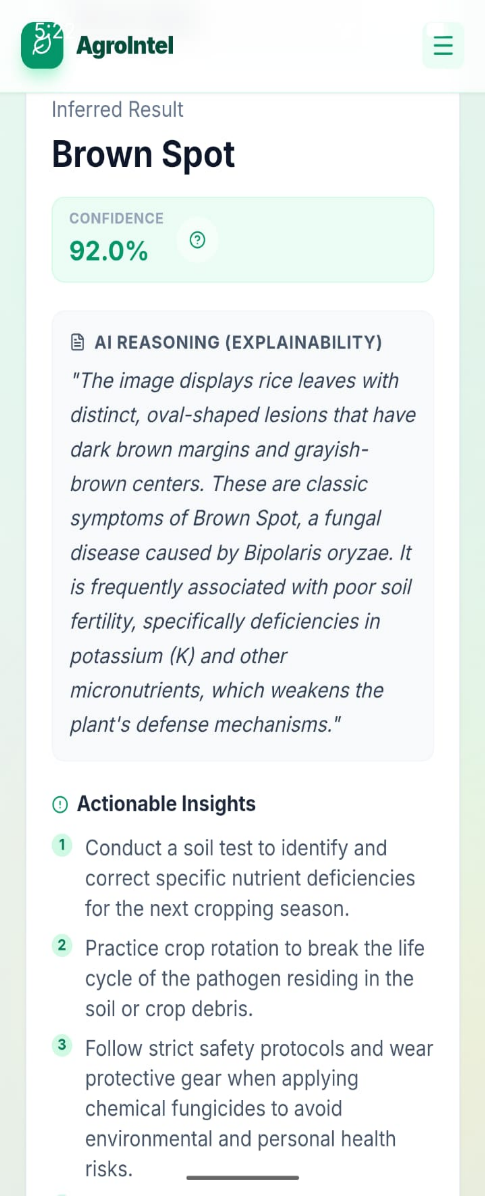
Brown Spot

CONFIDENCE 92.0%

Figure 2: Screenshot of Crop Yield Prediction Output

5.2Crop Yield Prediction Result

The yield prediction module estimates expected production based on soil and environmental inputs. The screenshot below shows the predicted yield output generated by the regression model.



Inferred Result

Brown Spot

CONFIDENCE

92.0%

AI REASONING (EXPLAINABILITY)

"The image displays rice leaves with distinct, oval-shaped lesions that have dark brown margins and grayish-brown centers. These are classic symptoms of Brown Spot, a fungal disease caused by Bipolaris oryzae. It is frequently associated with poor soil fertility, specifically deficiencies in potassium (K) and other micronutrients, which weakens the plant's defense mechanisms."

Actionable Insights

1. Conduct a soil test to identify and correct specific nutrient deficiencies for the next cropping season.
2. Practice crop rotation to break the life cycle of the pathogen residing in the soil or crop debris.
3. Follow strict safety protocols and wear protective gear when applying chemical fungicides to avoid environmental and personal health risks.

Figure 3: Screenshot of Market Price Forecasting Module

The results indicate that the integrated system provides reliable predictions and clear visu- alization outputs, enhancing practical usability for farmers.

6.Conclusion

The AgroVision project proves that we do not need expensive, high-tech hardware to solve one of the oldest problems in the world: how to grow food successfully. Imagine a farmer in a remote village who can’t afford a lab to test his soil or a expert to check his dying crops. By using AgroVision, that farmer’s smartphone becomes his laboratory.

The system works by connecting four different "brains" into one app. The first "brain" looks at pictures of leaves like a doctor and identifies diseases with 96% accuracy. The second and third "brains" look at soil chemicals and weather history to predict exactly how many bags of grain the farmer will harvest, so he can plan his finances early. Finally, the fourth "brain" studies market trends to tell the farmer when the prices will be highest, ensuring he doesn't sell his hard work for too little.

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