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CROP RECOMMENDATION USING EXPLAINABLE AI ALGORITHM

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ABSTRACT :

The Crop Recommendation System using Deep Learning and Explainable AI (XAI) aims to enhance agricultural productivity by providing farmers with precise crop suggestions tailored to their soil and environmental conditions. The system leverages deep learning models to analyze factors such as soil type, weather, pH, and nutrients, ensuring accurate recommendations. By integrating XAI algorithms, the system offers transparency and interpretability, enabling users to understand the reasoning behind the recommendations. This innovative approach not only optimizes crop selection for maximum yield but also empowers farmers with actionable insights, fostering trust and informed decision-making in sustainable farming practices. Additionally, the system supports real-time data integration for dynamic recommendations, adapting to changing environmental factors. It bridges the gap between advanced technology and traditional farming, making modern agriculture accessible to all. Ultimately, the solution drives sustainability and economic growth in the agricultural sector. Precision agriculture relies on intelligent decision-making to optimize crop selection based on soil conditions, climate, and other environmental factors. This study presents a crop recommendation system using machine learning to analyze soil properties, weather patterns, and historical yield data. The proposed model enhances agricultural productivity by providing farmers with data-driven insights for sustainable farming. Experimental results demonstrate improved accuracy compared to traditional methods. This approach contributes to efficient resource utilization and better crop management.

Keywords: Interpretability, Shapley Additive Explanations (SHAP), Decision Support System, Soil Analysis, Climate Variability, Crop Recommendation, Explainable AI (XAI), Machine Learning.

1. INTRODUCTION :

Agriculture plays a crucial role in ensuring food security and economic stability worldwide. Farmers face challenges in selecting the right crops for cultivation due to variations in soil type, climate, water availability, and market demand. A crop recommendation system helps farmers make informed decisions by analyzing factors like soil nutrients, temperature, rainfall, and past yield data. Such systems leverage technologies like machine learning, artificial intelligence, and data analytics to suggest the most suitable crops for a given region. By using these recommendations, farmers can optimize resources, enhance productivity, and minimize crop failure risks.

Traditional farming relies on experience and intuition, which may not always lead to optimal outcomes. In contrast, a scientific approach considers real-time data and predictive models to provide precise recommendations. Soil testing and remote sensing technologies further improve the accuracy of crop suggestions. Governments and agricultural organizations promote crop recommendation systems to improve yield quality and sustainability. Climate change and unpredictable weather patterns make these systems even more essential. They support precision farming, reducing excessive fertilizer and pesticide use, which benefits both the environment and human health.

Furthermore, integrating blockchain with crop recommendation ensures transparency and trust in agricultural supply chains. Farmers can receive real-time updates and access market insights to choose crops with high profitability. Digital platforms and mobile applications have made these recommendations accessible to even small-scale farmers. As technology advances, AI-driven models are expected to provide even more accurate predictions, benefiting global agriculture. The adoption of such systems contributes to sustainable farming, better food production, and improved livelihoods for farmers.

2. LITERATURE REVIEW :

2.1 Intelligent Crop Recommendation using Machine Learning

Author: Priyadharshini A Swapneel Chakraborty
Year: 2021

Agriculture is a crucial component of India's socioeconomic structure. A significant challenge arises when farmers struggle to select the most appropriate crops for their land, often relying on traditional and non-scientific methods. This issue is particularly pressing in a nation where nearly 58 percent of the

population is engaged in farming. In some instances, farmers fail to make informed decisions regarding crop selection based on soil conditions, planting seasons, and geographical factors. Such misjudgments can lead to dire consequences, including farmer suicides, abandonment of agricultural pursuits, and migration to urban areas in search of better livelihoods. To address this challenge, the present research proposes a system designed to aid farmers in making informed crop choices by taking into account various factors such as sowing seasons, soil characteristics, and geographical context. Additionally, the implementation of precision agriculture, which utilizes advanced agricultural technologies, is gaining traction in developing countries, focusing on site-specific crop management.

2.2 Crop Recommender System Using Machine Learning Approach

Author: Shilpa Mangesh Pande Prem Kumar Ramesh
Year: 2021
Agriculture and its allied sectors are undoubtedly the largest providers of livelihoods in rural India. The agriculture sector is also a significant contributor factor to the country's Gross Domestic Product (GDP). Blessing to the country is the overwhelming size of the agricultural sector. However, regrettable is the yield per hectare of crops in comparison to international standards. This is one of the possible causes for a higher suicide rate among marginal farmers in India. This paper proposes a viable and user-friendly yield prediction system for the farmers. The proposed system provides connectivity to farmers via a mobile application. GPS helps to identify the user location. The user provides the area & soil type as input. Machine learning algorithms allow choosing the most profitable crop list or predicting the crop yield for a user- selected crop. To predict the crop yield, selected Machine Learning algorithms such as Support Vector Machine (SVM), Artificial Neural Network (ANN), Random Forest (RF), Multivariate Linear Regression (MLR), and K-Nearest Neighbour (KNN) are used. Among them, the
Random Forest showed the best results with 95% accuracy. Additionally, the system also suggests the best time to use the fertilizers to boost up the yield.

2.3 Crop Recommendation Using Ensemble Stacking Machine Learning Approach

Author: Punith Kumar H N Champa
Year: 2023
Agriculture bears an impressively predominant position in the process of india's financial system expansion. In india, agricultural sector generates more employment opportunities than any other field. It constitutes 50% of the overall workforce of our country. Due to their less knowledge and ignorance of the various soil components and environmental factors, farmers choose the wrong crop for cultivation, which has a significant negative impact on agricultural productivity. The development of a system which provide a scientific approach to assist the farmers in forecasting the plentiful crops to be sowed based on several factors that affect the overall production is necessary to remove this barrier. Crop forecasting is essential for improving farming methods, reducing risks, assuring food security, and advancing sustainable farming. Across the agricultural value chain, it facilitates informed decision-making and effective resource allocation by offering insightful information about crop yields and production. This work utilize a data set that consists of soil parameters such as Nitrogen(N), Phosphorous(P), Potassium(K) and ph of the soil and weather parameters such as temperature, rainfall and humidity for 22 crops and applied ensemble stacking machine learning techniques to recommend crops with high accuracy and efficiency. Therefore, it can be beneficial for farmers to have greater versatility.

2.4 Crop Recommendation System For Precision Agriculture

Author: E. Ramanujam C. Kavya
Year: 2016
Data mining is the practice of examining and deriving purposeful information from the data. Data mining finds its application in various fields like finance, retail, medicine, agriculture etc. Data mining in agriculture is used for analyzing the various biotic and abiotic factors. Agriculture in India plays a predominant role in economy and employment. The common problem existing among the Indian farmers are they don't choose the right crop based on their soil requirements. Due to this they face a serious setback in productivity. This problem of the farmers has been addressed through precision agriculture. Precision agriculture is a modern farming technique that uses research data of soil characteristics, soil types, crop yield data collection and suggests the farmers the right crop based on their site-specific parameters. This reduces the wrong choice on a crop and increase in productivity. In this paper, this problem is solved by proposing a recommendation system through an ensemble model with majority voting technique using Random tree, CHAID, K-Nearest Neighbor and Naive Bayes as learners to recommend a crop for the site specific parameters with high accuracy and efficiency.

2.5 Adoption Of Precision Agriculture Technologies By German Crop Farmers

Author: Margit Paustian
Year: 2017
In recent years, there has been a growing interest among researchers in the field of precision farming. This approach offers a comprehensive system that enables farmers to effectively manage the spatial and temporal variability of crops and soil within their fields, ultimately aiming to enhance profitability, optimize yield and quality, and minimize costs. Significant research has been conducted on the adoption of precision agriculture technologies by farmers. However, many recent studies have focused on a limited number of factors. In contrast, this study examines a broad spectrum of farm characteristics and farmer demographics to better understand the key elements influencing the adoption of precision farming in German crop agriculture. The findings from a logistic regression analysis indicate that certain factors positively affect the adoption of precision farming, including the use of agricultural contractor services, having less than five years of experience in crop farming, possessing between 16 and 20 years of experience, and managing over 500 hectares

of arable land. Conversely, operating a farm of less than 100 hectares and cultivating barley are associated with a negative impact on the adoption of precision farming. The insights gained from this study offer numerous opportunities for advancing the implementation of precision agriculture technologies and guiding future research endeavors.

3 SYSTEM ANALYSIS :

3.1 Existing System

Crop recommendation systems encounter various challenges, primarily due to their dependence on static datasets that fail to reflect evolving environmental and climatic conditions. They frequently have difficulty processing sequential or time-series data, which diminishes the accuracy of predictions in dynamic agricultural contexts. Additionally, these systems often do not possess the ability to incorporate a wide range of factors, including soil characteristics, weather patterns, and historical crop information, which undermines the reliability of their recommendations. Moreover, conventional algorithms are susceptible to both overfitting and underfitting, adversely affecting their effectiveness in practical applications. Consequently, this leads to inadequate guidance for farmers, ultimately impacting both productivity and sustainability.

3.1.1Drawbacks

The drawbacks that have faced in crop recommendation are

- Data Dependency
- Technical Accessibility
- Cost of Implementation

3.2 Proposed System

The proposed Crop Recommendation System employs deep learning to analyze factors like soil type, weather, pH, and nutrients for precise crop suggestions. By integrating Explainable AI (XAI), the system provides transparency, allowing farmers to understand the reasoning behind its recommendations. It processes real-time and historical data for adaptive decision-making, ensuring context-aware outputs. The system bridges technology and traditional farming, promoting accessibility for farmers. This approach fosters sustainable agriculture by enhancing productivity and resource efficiency. The system begins by gathering comprehensive data on soil properties (e.g., pH, moisture, and nutrient levels), climatic conditions (e.g., temperature, rainfall, and humidity), water availability, and historical agricultural practices. This data can be collected through IoT sensors, soil testing kits, weather monitoring stations, and remote sensing technologies.

3.2.1 Advantages

The advantages of crop recommendation are

- Accurate Recommendations
- Resource Optimization
- Accessibility

4 TECHNIQUES OF CROP RECOMMENDATION :

In crop recommendation using Explainable AI (XAI), several techniques are employed to ensure transparency and interpretability:

1. **Feature Importance Analysis** – Methods like SHAP (Shapley Additive Explanations) and LIME (Local Interpretable Model-Agnostic Explanations) identify key soil, weather, and crop features influencing recommendations.
2. **Decision Trees & Rule-Based Models** – Algorithms like Random Forests and XGBoost provide interpretable decision paths for crop selection.
3. **Attention Mechanisms** – In deep learning models, attention layers highlight critical input factors affecting predictions.
4. **Counterfactual Explanations** – Shows how slight changes in soil or weather conditions alter the recommended crop.
5. **Partial Dependence Plots (PDPs) & Individual Conditional Expectation (ICE)** – Visualize relationships between input variables and crop recommendation outcomes.

5 CONCLUSION :

A Crop Recommendation System utilizing Deep Learning presents a robust and effective approach to enhancing agricultural practices. By employing sophisticated machine learning algorithms and data-driven analyses, the system delivers accurate crop recommendations based on a variety of factors, including soil quality, climatic conditions, and environmental influences. The incorporation of Explainable AI (XAI) guarantees clarity in the decision-making process, enabling users to comprehend the reasoning behind the recommendations. This fosters trust and equips farmers with practical insights to boost crop yields and promote sustainable farming practices. With ongoing updates and improvements, such a system can adjust to evolving agricultural circumstances, rendering it an essential resource for advancing productivity, sustainability, and informed decision-making in the agricultural sector.

6 FUTURE ENCHANCEMENT :

- It can focus on integrating AI and machine learning to improve prediction accuracy based on real-time weather, soil quality, and market demand. The use of IoT sensors and satellite-based remote sensing can enable continuous monitoring of soil conditions and climate variations, ensuring timely recommendations.
- Blockchain technology can enhance transparency in the agricultural supply chain, helping farmers get fair prices and reducing fraud. Developing a user-friendly mobile app with multilingual support and voice assistance can improve accessibility for farmers in rural areas. Additionally, incorporating climate resilience models can help suggest drought-resistant or flood-tolerant crops, ensuring sustainability in the face of climate change.

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