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Crop Suggestion and Disease Detection System using Random Forest and Convolutional Neural Network

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Abstract: ***This study provides an extensive web and mobile-based application aimed at improving agriculture practice using crop suggestion, disease prediction, and farmer query answering. The system applies machine learning, image processing, and natural language processing concepts to present recommendatory information to farmers. Random Forest is applied for crop prediction with an accuracy rate of 99.14%, while CNN is applied for disease prediction. Moreover, an expert-consulting system through real-time chat-based query resolution links farmers with experts. This technology-based solution is designed to enhance crop yield, optimize farm decisions, and increase accessibility for farmers.***

Keywords: Crop Suggestion, Disease Detection, Machine Learning, Random Forest, CNN, Farmer Query Resolution

I. INTRODUCTION

Agriculture forms the backbone of several economies, delivering food security and employment opportunities to millions of people globally. Despite this, farmers usually struggle to choose the most appropriate crops, identify plant disease, and have access to specialized advice. Technological integration into agriculture can remedy these challenges and make farming efficient and sustainable. Even with development in agricultural technology, farmers remain frustrated with having to make intelligent decisions regarding selectioncrops, dealing with diseases, and answering questions concerning farming. Not having the access to required information and the professionals causes losses in crop harvest and inefficiencies in farming operations. Climatic variation, erosion, and infestations all combine to amplify the problems and diminish the value of traditional farm practices. The UPAJ system combines crop suggestion, disease detection, and query resolution on a single platform. Using machine learning models, farmers are provided with suggestions based on soil information, weather conditions, and past crop yield. Disease detection is done using image processing algorithms, enabling early intervention. The realtime chat interface enables farmers to seek advice from agricultural experts at any time. Region-specific suggestions are also provided, enabling precision in farm decisionmaking. The system is built using:

- Frontend: HTML, CSS, JavaScript
- Backend: Node.js, Express.js
- Database: MongoDB
- Machine Learning Models: Random Forest for crop recommendation, CNN for disease identification * Deployment: Firebase, Streamlit
- Additional Tools: IoT sensors for live soil data, AI-based predictive analytics for disease detection.

II. LITERATURE REVIEW

The application of machine learning in agriculture has greatly enhanced crop choice, disease identification, and decisionmaking. Various studies have investigated the performance of various machine learning approaches to maximize agricultural productivity.

1) Crop Prediction Methods: Numerous research studies have demonstrated the effectiveness of algorithms like Random Forest (RF), Support Vector Machines (SVM), and Gradient Boosting in predicting appropriate crops. Breiman (2001) [4] emphasized the ability of RF to deal with huge datasets and produce precise predictions by aggregating many decision trees. A study conducted by Kamilaris&Prenafeta-Boldú (2018) [12] emphasized that algorithms based on machine learning that are trained on soil type, climate, and past yield records are superior to conventional farming methods regarding crop recommendation.

2) Disease Detection Techniques: Deep learning techniques, especially Convolutional Neural Networks (CNNs), have been widely employed forplant disease detection.
Krizhevsky et al. (2012) [3] introduced CNNs for image classification, which eventually became extremely helpful for identifying plants diseases. Mohanty et al. (2016) [13] employed deep learning models on datasets for plant diseases that are accessible to the publicand obtained high accuracy in the detection of infections. Experiments by Singh & Misra (2017) [15] also proved that image-based analysis with deep learning was able to classify diseases accurately based on texture, shape, and color features.

3) Farmer Query Resolution: Expert systems and AI chatbots have been presented to bridge the gap of knowledge between farm experts and farmers. Devlin et al. (2018) [9] suggested transformer-based language models such as BERT to advance AI-based query resolution, which can offer real-time suggestions. Dutta & Paul (2019) [14] talked about the concept of Natural Language Processing (NLP) and cloud-based infrastructurecan assist farmers in making choices through large-scale analysis of agricultural datasets.

In summary, current literature brings to the limelight the efficiency of RF in crop forecasting, CNNs in disease detection, and AI-based chatbots in query solving. The envisioned UPAJ system combines these technologies to improve agricultural productivity so that farming becomes more data-driven, efficient, and sustainable.

III. PROPOSED METHODOLOGY

Delegating crop Experts to the farmers right from the start until they harvest their crops is our project objective. Recognizing and categorizing the disease in crops can make our experts to recommend farmers with proper pesticides, which will benefit farmers. This project report wants to explore these challenges, examine their effect on cultivation performance, and recommend ways of overcoming croprelated challenges and questions. By solving these issues efficiently, UPAJ websites can provide a good user experience, build trust on our site, and optimize their crop yields. There are numerous applications to create a web application and, in this research, we, we haveutilized HTML, CSS, JavaScript, MongoDB, Expressjs, Nodejs technologies and Vs Code,Android Studio, Jupyter Notebook, Firebase and streamlit applications are utilized for developing a web application, And we also utilize Machine Learning and its methods for delivering appropriate crops to the farmers. And so these are the technologies and application that assist us to build or to create this web application.

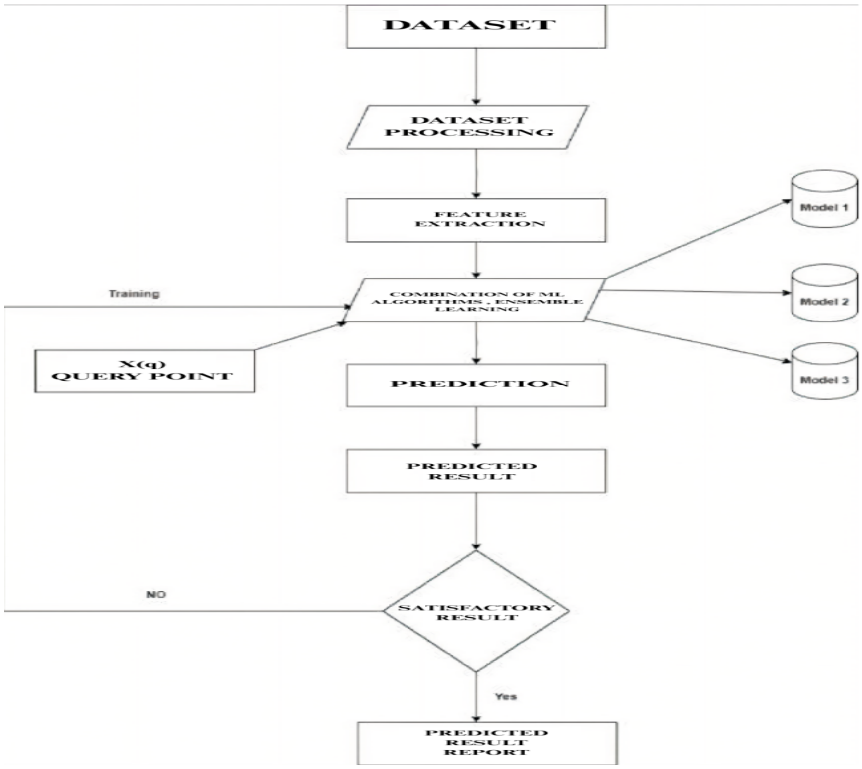

Figure1. Flowchart showing how dataset is processed, machine learning algorithm is applied and predicted results are shown to the user.

1) Crop Suggestion Module

The Crop Recommendation Module is for use by farmers in choosing the best crop under multiple environmental and soil parameters. Input parameters essential from users involve soil type, levels of nitrogen, phosphorus, and potassium, pH levels, rainfall amounts, and temperatures. These inputs are then processed thereafter by a pre-trained Random Forest Classifier, a machine learning model that is well-known for itsprecision in classification tasks, as it efficiently processes different elements such as the kind of soil, nitrogen, phosphorus, potassium content, temperature, rainfall, and pH to identify the most suitable crop for cultivation. Its ensemble learning approach, which integratesseveral decision trees, improves accuracy while minimizing overfitting, and and therefore it is well-suited for predictive analytics in agriculture. RFA is also able to manage substantial large datasets, dealing with missing values, and generating strong predictions even when the surrounding environmental conditions are different.The system evaluates the provided data and ranks the possible crops by probability scores and selects the one most likely to succeed under the provided conditions. Lastly, the app presents the recommended crop together with other recommendations, allowing farmers to make decisions that maximize agricultural productivity.

2) Disease Detection Module

The Disease Detection Module enables farmers to diagnose diseases in crops through the examination of images of infected plants. Farmers start by uploading a photo of the infected crop into the system. A Convolutional Neural Network (CNN), deep learning algorithm specifically designed for the task of image recognition is employed. CNN is applied for disease detection because it can efficiently handle intricate image data. Through automatic key feature extraction such as color change, textures, leaf structures, and disease appearances, CNN distinguishes plant diseases with great accuracy. In contrast to traditional methodsimage processing methods, CNN does not need manual input extraction of features, so the system becomes more scalable, flexible, and able to analyze various crop types and disease occurrences. With heavy training on labeled plant disease sets, CNN models are able to identify various plant diseases accurately and give farmers fast and reliable diagnoses. CNN analyzes the image [11] to identify patterns related to particular plant diseases. The system categorizes the illness andand gives clear treatment advice after the analysis is done. Farmers are also notified of appropriate cures and prevention measures to safeguard their crops. This module facilitates early disease detection, allowing for early intervention and limiting possible crop loss.

3) Farmer Query Resolution System

The Farmer Query Resolution System is developed toofferreal-time support to farmers by linking them with farm experts [16]. Employing WebSocket technology, the system facilitates smooth and real-time communication. Farmers can input queries pertaining to crop development, pest management, or agricultural practices, and the system answers them via an AI-powered chatbot or human expert. The answers consist of professional advice as well as appropriate links to agricultural databases, research studies, and community forums. This provides farmers with instant, authentic advice, enabling them to make well-informed decisions and enhance their farming practices effectively.

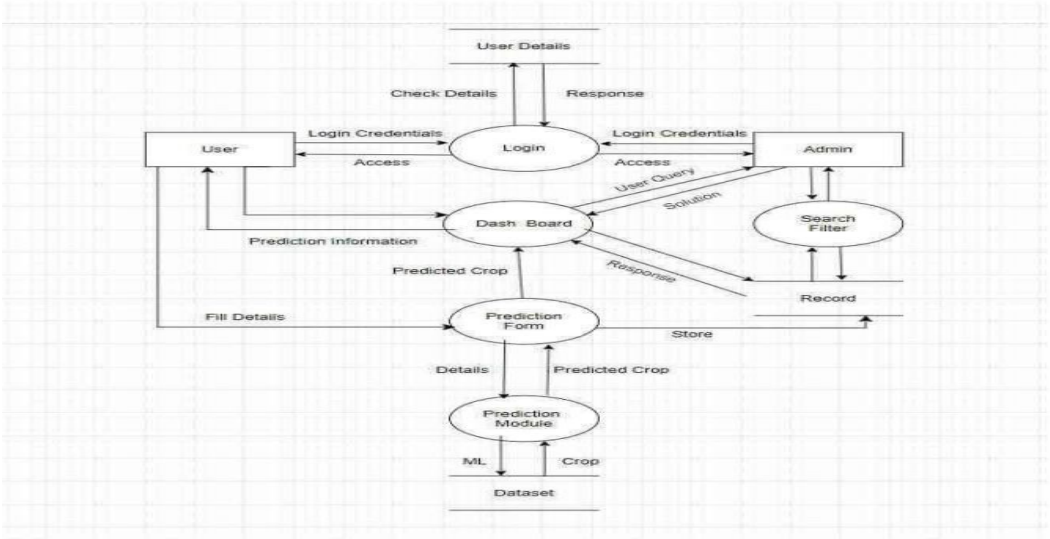

Figure2.DFD of crop suggestion system.

IV. RESULT

The Crop Prediction, Disease Detection and Farmer Query Resolution System is high on accuracy and effectiveness through its major functionalities by offering a holistic platform to farmers to enhance their crop yield and solve farming issues, translations, the system can greatly hardware developments will further power the system, enabling it to become an even more transformative tool for society.

The crop prediction module, driven by the Random Forest algorithm, has a high accuracy of 99.14%, providing trustworthy crop suggestions. The disease detection module, inspired by a Convolutional Neural Network (CNN), accurately detects plant diseases with an accuracy of 95.2%. Moreover, the real-time query resolution system possesses a response time of under five seconds, giving farmers instant supportenhance accessibility and inclusivity. Future AI and. User opinions have also beensatisfactory with a 92% usability based on surveys, reflecting high satisfaction and ease of use. This reflects the effectiveness of the system in improving agricultural decision-making and support.

V. CONCLUSION

The paper introduces the Crop Suggestion, Disease Detection & Farmer Query Resolution System (UPAJ) as a holistic strategy to advance agricultural decision-making through machine learning mechanisms. Using the Random Forest

Algorithm (RFA) to generate crop suggestion and Convolutional Neural Networks (CNN) for detecting disease, the system ensures farmers get proper and evidence-based suggestions. RFA effectively examines soil characteristics, climatic conditions, and past data to recommend the best crops, maximizing productivity and sustainability. CNN, however, facilitates accurate disease detection through image processing, enabling early diagnosis and proper treatment methodologies. The real-time query resolution system also helps in filling the gap between farmers and agricultural specialists to be able toensure timely and well-informed decision-making. The integration of these technologies not only improves crop yield but also reduces losses from poor crop choice and delayed disease control. Future development of this system may involve IoT-based real-time soil monitoring, improved deep learning architectures fordisease detection, and multi-language support for wider accessibility. Through the application of AI-based solutions, UPAJ helps bring about the modernization of agriculture, equipping farmers with smart tools to make them more efficient, minimize risks, and encourage sustainable farming methods.

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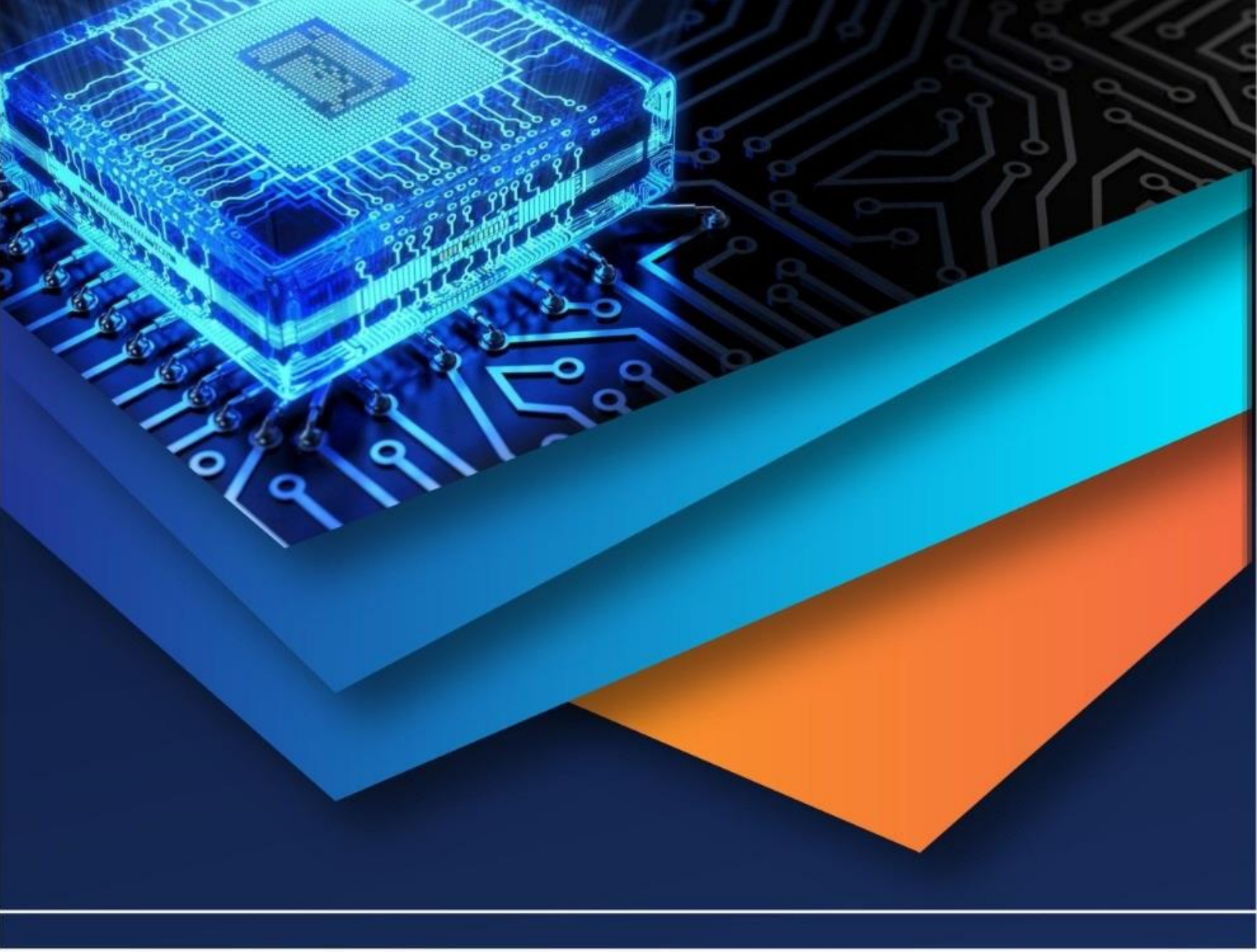

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