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Soil Analysis and Crop Recommendation using Machine Learning

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Abstract:

India forms a part of the top three makers of several different crops worldwide and serves as a well-known agriculture center. While Indian farmers play a crucial part in agriculture business, a large percentage of them are still at the lower end of the social scale. Even with a few technology fixes, farmers still struggle to recognize the most lucrative and viable crops for their land given the variety of soil types in different parts of the world. This study presents a crop suggestion system that predicts the best crop drawn from a thorough examination of several factors, including location, kind of soil, yield, price upon sale, and more. It does this by using both a Convolutional Neural Network (CNN) design and a Random Forest (RF) Model. An accuracy rate of 75% is anticipated from the CNN design, while the RF Algorithm may produce an accuracy rate of 98%.

Index Terms- Random Forest, Image classification, Deep learning, Convolutional Neural Network, MobileNet v2.

1. INTRODUCTION:

Two-thirds of India’s people directly rely on agriculture for their livelihoods, rendering it a traditional and ongoing pillar of the country's economy. Interestingly, it accounts for 20% of India's GDP (GDP). In the center of agricultural industry is the farmer, our country's Anna Datta (Food Provider), who faces a number of difficulties these days:

1) Since there are so many different kinds of soil within the nation, farmers often struggle to choose the best crop for their particular soil, climate, and area, which may result in large losses.

2) As weather patterns are unpredictable, farmers have significant difficulties in calculating profitability and forecasting yields for certain planting seasons.

3) The 'farm to market' method, which involves several middlemen who eat a sizeable percentage of income via the transportation and selling of products, is the reason of the meagre profits obtained by farmers for their goods.

AI and ML technologies have several uses in the contemporary agriculture sector. For example, crop recommender systems and precision agriculture can forecast yields, identify plant pests, improve overall quality of harvests, and solve nutrient deficits in farms. AI system integration has the capacity to revitalise the struggling agriculture industry.

There exist significant apprehensions regarding the future of the farming industry in India given the present state of affairs. The agriculture industry confronts difficulties even though it employs about two thirds of the workers and contributes 20% of the GDP. Because they lack collateral, almost all Indian farmers—about 85% of them—operate on fewer than five acres of land, assuming significant product and market risks every season. Due to poor literacy rates, smallholding farmers—who account for half of agricultural output and 46% of cultivated land—often find themselves shut out of contemporary market structures like contract farming and direct purchasing.

1.1 BACKGROUND:

The model's objective was to use the most widely available technology, such SMS and email, to suggest crops to even the tiniest farmer at the extent of his or her smallest agricultural plot.

1.2 OBJECTIVES:

This research project's primary objectives are to solve persistent issues in the agriculture industry, regardless of local or regional circumstances. The goal is to enhance the ordinary farmer's profitability by using machine learning. The main objectives include creating a cutting-edge technology to enable farmers to choose crops wisely. This study also describes the conception and execution of a website that serves as a marketplace between agricultural purchasers and farmers, removing the necessity for middlemen.

1. Optimizing Crop Selection: Resolving the conundrum Indian farmers have in choosing the most lucrative and appropriate crops for their soil, especially considering the variety of prevalent soil types in different regions of the country.

2. Leveraging Advanced Technologies: Ensuring that farmers can profit from the newest advancements in agriculture by overcoming the current barriers to obtaining modern technical solutions.

3. Site-Specific Features: Addressing the requirement for site-specific data, in particular the chemical composition of the soil, but also noting the difficulties and financial ramifications that farmers may have in gathering this kind of information.

4. Improving Profitability: By giving farmers useful information via a strong crop recommendation system, it can assist them in becoming more profitable in their farming pursuits.

5. Cutting Out Middlemen: In order to cut down on the number of middlemen in the farming supply chain, a digital tool has been created that works as a simple marketplace for farms and people who want to buy crops.

2. RELATED WORK:

The research on crop prediction and soil classification in agriculture is compiled and analyzed in this part.

Using data mining methods, Pudumalar et al. [1] created a recommender system for precision agriculture. Their strategy included the CHAID, Random Tree, Naive Bayes, and K-Nearest Neighbor models in an ensemble technique with majority voting. The advice received support from studies on crop yields, soil properties, and kinds.

An ensemble model combining ANN and support vector machines, Random Tree, and Naive Bayes models with a majority voting method was proposed by Rajak et al. [2]. The dataset included several soil properties, such as pH and water density, gathered from university and soil testing facilities.

A two-step strategy for crop recommendation and soil categorization was presented by Reddy et al. [3]. During the subsequent phase, consideration was given to characteristics like soil series, temperature, humidity, rainfall, and ph, the initial phase used chemical properties of the soil to forecast the soil series or type. For crop suggestions, Support Vector Machine, K-Nearest Neighbors, and Bagging were among the categorization strategies put out.

Venugopal et al. [4] projected yield values using the Random Forest, Naive Bayes, and Logistic

Regression techniques and suggest appropriate crops. To train their models, historical data on temperature, weather, and other variables were gathered; the Random Forest Algorithm produced the best accuracy.

A Crop Selection Method (CSM) was presented by Kumar et al. [5] aiming to increase crop net yield rates. The plan called for planting a series of crops in a season while taking a number of variables into account, including crop type, weather, soil type, and water density. The significance of crop selection was emphasized, along with its influencing variables, encompassing market price, government policy, and production rate.

Data mining methods were utilized by Ahamed et al. [6] to estimate the crop production of cereal crops in Bangladesh. Their technique used KNN, linear regression, and artificial-neural-networks in the quick miner tool for categorization and clustering to create district clusters.

The approach presented by Mahendra et al. [7] forecasts the ideal crop based on soil properties such as pH, moisture content, and rainfall. While crop production was projected using the Decision Tree approach, rainfall was predicted using the SVM technique.

3. METHODOLOGY:

The two-step crop suggestion model in the suggested technique is easy to utilise. On a specific webpage, users have the choice to submit soil photos or enter reports on certain soil features, such as moisture, phosphorus as well as nitrogen levels. Following the required inputs, the system analyses the information to provide a list of crop suggestions based on expected gross income, quality, and yield. This approach offers a smooth experience for both image-based and feature-based inputs, accommodating users spanning a broad spectrum of preferences.

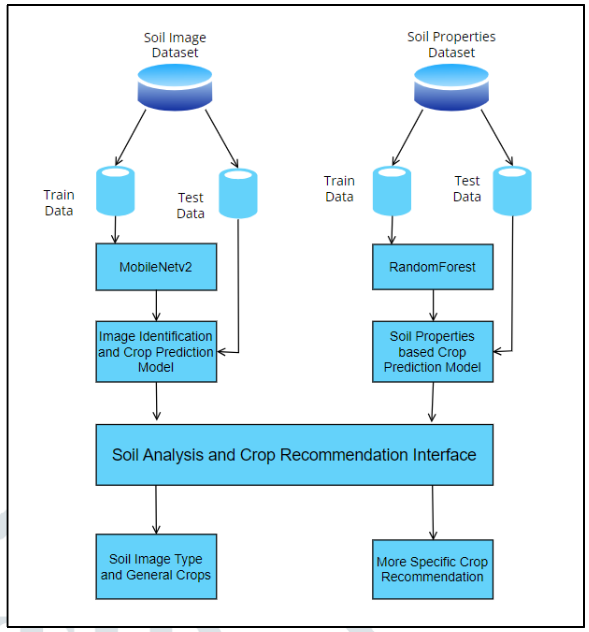

Fig.1. System Workflow

The technique can be segmented into two integral components that are meant to provide accurate crop recommendations and efficient soil categorization.

Step 1: Using MobileNet v2 architecture for Soil Image Identification.

➢ Mobilenetv2:

For embedded and mobile devices, MobileNetV2 is a deep learning architecture.
To achieve effective image recognition, it makes use of depthwise separable convolutions and inverted residual blocks. An description of the algorithm's operation may be found below:

Algorithm:
1.Input picture: The procedure begins with the application of a picture input.
2. Completely convolutional layer: A completely convolutional layer is utilised to extract the first features from the image.
3.Inverted residual blocks: Following that, the features are subjected to many iterations of inverted residual blocks. Each block expands the input channels and applies depth-wise filters before shrinking the channels to the desired output dimension. The shortcut connection ensures that information flows across the network effectively.
4.Bottleneck residual blocks: Downsampling

uses these blocks. To even lower the quantity of channels these blocks include an additional 1x1 pointwise convolution prior to the 3x3 depthwise convolution.

5. Average pooling layer: To reduce the final feature map's size, an average pooling layer is used.

6. Classification layer: The pooled characteristics are then passed into a classification layer, which uses them to forecast the category of the input image.

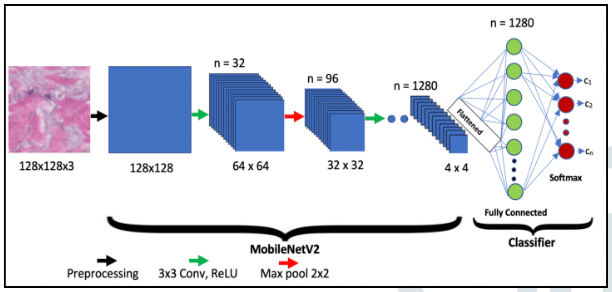

Fig.2. MobileNet v2 architecture

Classifying Soil using MobileNetV2: Initially, this system interprets input from images or soil attributes using the Convolutional Neural Network (CNN) MobileNetV2. This sophisticated neural network assesses the soil input based on many characteristics, such as moisture, phosphate, and nitrogen, and analyzes it to create multiple soil types. The next sections go into further depth about the MobileNetV2 implementation. After classifying the soil, the algorithm selects the crops with the highest likelihood of thriving in the designated soil type, ensuring that the crops are suggested match the properties of the soil for optimum results.

Step 2: Applying the Random Forest Algorithm to crop prediction in relation to soil properties.

➤ RandomForest:

A supervised learning technique called the Random Forest method aggregates predictions from several decision trees to improve overall accuracy and control overfitting.

Algorithm:

1.Data preparation:

Multiple replacement subsamples are created from the training set.

For each subsample, a random selection of attributes is made.

2.Decision tree construction:

Using the selected attributes, a decision tree is built on each subsample.

The tree keeps growing until it reaches a certain depth or meets additional requirements.

At each node, the best split is chosen based on an impurity measure.

3.Prediction:

Every decision tree in the forest provides a forecast for a fresh data point.

The ultimate forecast for categorization is determined by the majority vote of the trees.

The average forecast made by the trees is employed in regression.

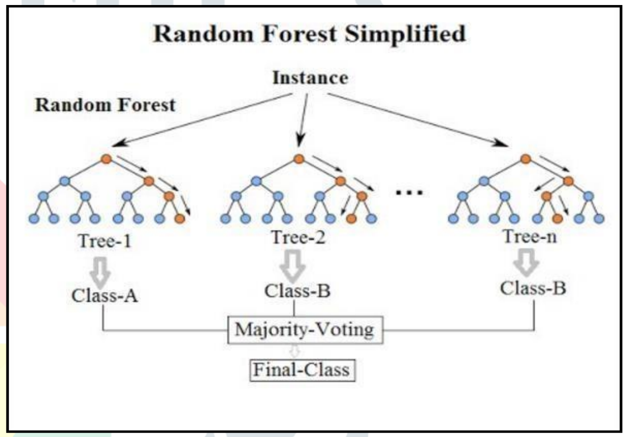

Fig.3.Working of Random Forest Algorithm

In our project, the Random Forest Algorithm is applied to recommend crops based on specific soil properties, such as Nitrogen, Phosphorus, and Potassium (NPK) levels, moisture content, temperature, and other environmental factors. With the help of this method, we may examine a wide range of soil-related data and recommend crops that have the best chance of succeeding in particular conditions. Through the use of this algorithm's findings, farmers are able to make informed decisions on crop selection, therefore optimising yields and resource utilisation in accordance with the unique features of their particular land. This systematic approach enables the model to deliver comprehensive and tailored crop recommendations by integrating soil attributes and economic feasibility, hence enabling an all-encompassing agricultural decision-making process. The Random Forest Algorithm and the specifics of MobileNetV2 implementation are described in the following sections of this survey article.

4. OBSERVATION AND RESULTS :

4.1 WEB PORTAL

The UI in our soil analysis and crop suggestion project flowed well, as we saw. The index page of the UI presents users with two choices: log in or register. Users enter the system by registration, which takes them to the dashboard, which is the main core of functionality. Users are presented with two primary choices inside the dashboard: crop prediction based on soil parameters and crop forecast using soil picture identification. With respect to the former, users are able to submit a picture of their soil and get predictions about the kind of soil in addition to suggested crops that may be grown there. Users may also utilize the latter technique, which needs adding exact soil characteristics like pH, humidity, and NPK levels, to further fine-tune their crop choices. This procedure makes sure that consumers get customized crop suggestions that are supported by thorough soil investigation.

In addition, the user interface makes things simpler and easier to use, which improves productivity and accessibility. The user interface (UI) facilitates ease of use and engagement by offering users obvious routes to explore the system, from registration to accessing the primary features.

Fig.4. Crop Recommendation Based on Soil Image.

To accommodate different user preferences and needs, crop suggestions may be obtained in a flexible manner thanks to the integration of both image-based and characteristic-based crop prediction options.

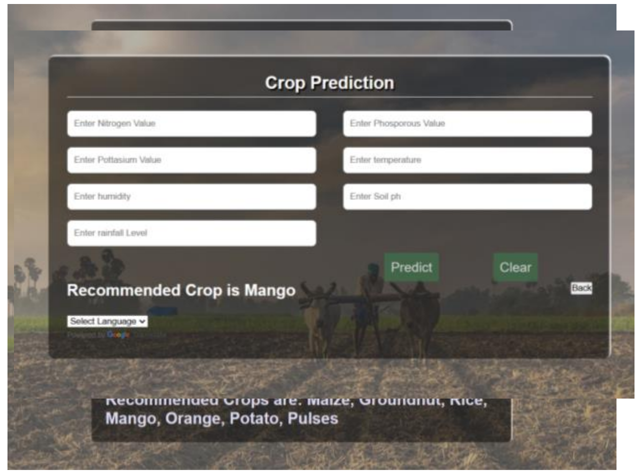

Fig.5. Soil Properties Based Crop Recommendation.

Furthermore, the user interface's simple design reduces complexity, making it easy for users to enter soil data and get accurate crop recommendations. All things considered, the project's usefulness is greatly enhanced by the fluidity and intuitiveness of the user interface (UI), which enables users to make well-informed judgments about crop production based on thorough soil analysis.

4.2 PERFORMANCE ANALYSIS

We used two different approaches in the performance study of our project: the Random Forest (RF) algorithm and the MobileNetV2 architecture. We obtained excellent results using the RF method, with training and validation accuracy reaching a staggering 98%. This high accuracy shows how well the RF technique predicts soil types and suggests appropriate crops based on input data.

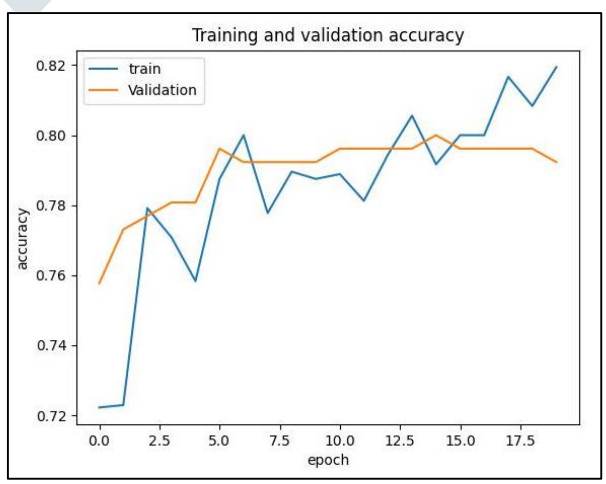

Fig.6. MobileNet v2 accuracy

On the other hand, outcomes using the MobileNetV2 architecture were somewhat worse but still rather good. MobileNetV2's capacity to accurately categorize soil photos and propose crops was shown by its 82% average training and validation accuracy.

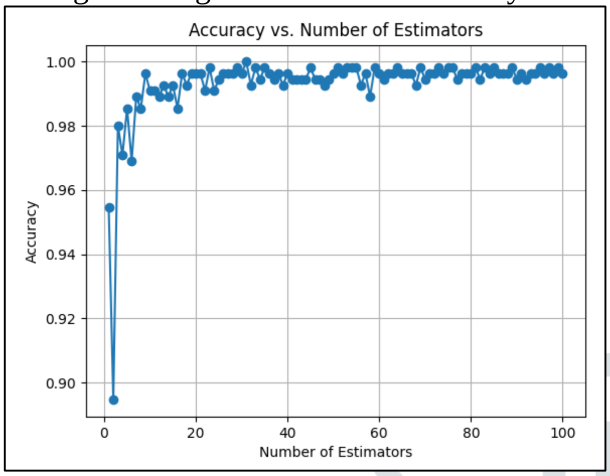

Fig.7. RandomForest accuracy

One advantage of MobileNetV2 is that it's a lightweight and effective model, which makes it well-suited for deployment in resource-constrained contexts like mobile devices or edge devices, even if its accuracy is somewhat lower than that of the Random Forest method. The performance study, taken as a whole, demonstrates the advantages of both approaches and offers users solid and reliable crop suggestions derived from soil research.

5. CONCLUSION

The research report emphasizes how modern technology has completely changed India's agricultural environment. The crop suggestion system's combination of Random Forest and CNN models has shown remarkable accuracy rates of 98% and 82%, respectively. These models are crucial for more accurate crop selection since they account for a wide range of factors, such as soil types and local conditions. The research recognizes MobileNetV2's effectiveness in real-time applications and the RF Algorithm's excellent performance in predicting crop production.

With its direct marketplace architecture, the suggested online platform offers direct access to markets, reducing the need for intermediaries and streamlining the supply chain while empowering farmers.Machine learning-based crop recommendation systems has the accuracy, personalization, scalability, and flexibility to possibly revolutionize conventional agriculture techniques, resulting in more sustainable and efficient results.

In the future, the paper suggests further investigation into creative approaches to support and grow India's agriculture industry. Increasing farmer access to innovative technologies via user-friendly channels is a major area for development.By putting communication channels like email and SMS into practice, small farmers will be able to make better decisions by getting timely information and advice on market trends, crop selections, and weather predictions.

Furthermore, by adding technologies like blockchain for traceability, AI-driven weather prediction, and real-time crop monitoring via IoT devices, the platform's capacity to link farmers with customers directly may be increased. Adding more ML algorithms might improve crop suggestions' accuracy and dependability, making the system stronger overall. These improvements might bring the agriculture sector back to life and help India's farmers enjoy a more resilient and sustainable future.

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