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Design And Implementation Of Soil Classification And Crop Suggestion Using Machine Learning

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Abstract:

Soil is a critical factor for a successful agriculture. The Growth of Crops is affected by the chemical features of soil. Choosing the right type of crops for that particular type of soil is also important. Machine Learning techniques can be used to classify the soil series data. The results of such classification can further be combined with crop dataset to predict the crops that are suitable for the soil series of a particular region and its climatic conditions.

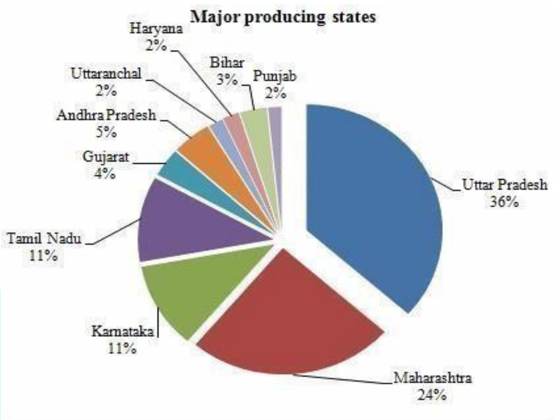
Predicting a crop well in advance requires a systematic study of huge data coming from various variables like soil quality pH, N, P, K etc. As Prediction of crop deals with large set of database thus making this prediction system a perfect candidate for application of data science. The success of any crop prediction system heavily relies on how accurately the features have been extracted and how appropriately classifiers have been employed.

Index Terms - Soil classification, Crop prediction, Machine learning, Data science, Soil quality analysis, Feature extraction, Soil–crop suitability, Precision agriculture, Crop recommendation system

I. INTRODUCTION

Agriculture production a very important factor for Indian economy and sufficient food supply for the current population is big issue. Majorly the crop lands hold is of type small/marginal scale. Precision agriculture systems which gives decision about which crop is to adapt for better yield according to current scenario are costly and based on satellite, image processing technologies etc. Whereas the crop production is dependent on natural parameters like soil and environment. Various machine learning techniques has been used. For small/marginal scale farmers appropriate, user friendly and low-cost system is needed. As these farmers prefer nature dependent rainfed cropping, those natural parameters need to be considered while taking decision regarding precision agriculture system. Various machine learning techniques are available which can predict the suitability level according to input and training data-set. Those machine learning models are compared with the hybrid approach and performance of each algorithm is discussed in detail.

Agriculture is having a great impact on the country's economy. In the last decade India has seen serious natural calamities like drought or flood. Due to such disasters, there is a huge loss to crop production and ultimately to the farmers. Due to such financial loss many farmers are committing suicide. If natural calamities are not present then there may be sudden pest attack destroying the crop. In any case farmer and the crop are always at the edge of risk. Government policies are there but that is not sufficient. Figure 1. shows the major crop producing states of India. Prediction of suitable crops in advance can help the farmers and the Government bodies to plan for storage, selling, fixing minimum support price, importing /exporting etc.



Source: Ministry of Agriculture, GoI

Objectives:

- System objective is to estimate or forecast the suitable crops and Soil Classification.
- IOT device used to fetch the parameters used for soil classification.
- System recommends suitable crops to improvise crop yield.
- Proposed system makes use of machine learning in agriculture for decision making.
- System uses "supervised learning" technique - Naive Bayes Algorithm for crop prediction and "KNN" algorithm for Soil Classification.
- System makes use of SQL Serve to store the previous agriculture data.
- Proposed system is a real-world application which is meant for agriculture departments.

II. PROBLEM STATEMENT

In agriculture field, farmer has to know about the suitable crops for cultivation. Growing crops are completely based on the type of the soil and its features, location, whether etc. Now a days analyzing soil and its features are entirely manual which requires more time. This leads to the development of the automation for crop prediction based on the soil features. Precision agriculture systems which gives decision about which crop is to adapt for better yield according current scenario are costly and based on satellite, image processing technologies etc.

III. PROPOSED SYSTEM

Proposed system contains 3 major objectives, one fetching soil features from IOT decide, and secondly suggesting the suitable crop based on the environment conditions and finally soil classification is also suggested by the system. Machine learning algorithms applied to analyze data and soil classification and suitable crops. Data-sets collected from agriculture departments. Rainfall, temperature, pH value, nitrogen, potassium, zinc, phosphorous, iron etc.. all these parameters are used for recommendation. System developed as real time application which is useful for agriculture departments and farmers.

We use suitable technology to work with real time application, that is "visual studio" as front-end technology and "SQL server" as back-end technology. These technologies are preferred because it supports more suitable libraries, tools and concepts required to work with real time application compared to other technologies. Proposed system helps farmers to cultivate right type of crops in right time and also helps farmers to increase crop yield based on soil classification. Major population in India will benefit from this application. Supervised learning algorithms used for the recommendations such as either "Bayesian classifier" or "K nearest neighbor" or "Random Forest" algorithm. These algorithms are preferred as they work efficiently, generated faster results and also work for all formats of data. And also, few survey papers suggest these algorithms are efficient and good for agriculture data-sets.

IV. LITERATURE SURVEY

Literature Survey on Object Detection Using Deep Learning

Author(s) & Year	**Dataset**	**Methodology / Research Focus**	**Algorithms / Models**	**Key Outcome**
Sharvani V. et al. (2020) – IRJET	Soil dataset from private soil lab, Pune	Automated system for soil classification and crop suggestion based on fertility classes	Naïve Bayes, J48, JRip	Faster and more reliable soil classification compared to manual methods; helps suggest suitable crops and fertilizers
Jagdeep Yadav et al. (2021) – IJRAE	(i) Soil dataset (15 attributes: pH, EC, N, P, K, micronutrients, etc.) (ii) Crop dataset (temp, humidity, rainfall) (iii) Yield dataset (N, P, K, temp, pH, organic carbon)	Multi-dataset integration for soil fertility classification, crop recommendation, and yield prediction	Naïve Bayes, J48, JRip	ML algorithms effectively classified fertility and predicted yield; integrating soil, crop & yield data improved accuracy
Jagdeep Yadav et al. (2021) – IJRAE (Extended work)	Same as above	Data preprocessing, training/testing split, supervised learning experimentation	Various supervised ML algorithms	Demonstrated improved prediction accuracy with preprocessing; highlighted importance of training/testing data division
Pragati Kanchan & Nikhilkumar	Soil parameters, crop season, weather data	Farmer support system (Krashignyan) for crop	Decision Tree, Random Forest, Naïve Bayes,	XGBoost classifier achieved highest

Shandoor – Asian Journal of Convergence in Tech		recommendation	XGBoost	accuracy in recommending suitable crops for Pune district
N. Laxmi Kalyani & Kolla Bhanu Prakash (2022) – IJACSA	Soil color images	Fertility estimation using deep learning-based image analysis	CNN (ConvNet with Convolution, ReLU, Pooling, FC layers + SoftMax)	

V. EXISTING SYSTEM

In the existing system, traditional approaches to crop prediction and soil analysis mainly rely on **manual observation**, **historical yield data**, and **basic statistical models**. Farmers often make decisions based on experience or generalized recommendations, which may not always be accurate for different soil and climatic conditions.

Some recent systems have attempted to integrate **machine learning** into crop prediction and soil classification. These systems typically work by:

Soil Classification

- Using soil datasets containing chemical parameters such as **pH, Nitrogen (N), Phosphorus (P), Potassium (K), organic carbon, and moisture content**.
- Applying classification algorithms like **Decision Trees, Random Forest, K-Nearest Neighbors (KNN), and Support Vector Machines (SVM)** to categorize soil into suitable classes.

Crop Recommendation Systems

- Predicting the best crop for a given soil type and climatic condition by training ML models on **soil and crop datasets**.
- Models like **Naïve Bayes, Logistic Regression, and Artificial Neural Networks (ANNs)** have been used in past studies.

Limitations of Existing Systems

- **Lack of accuracy** due to small and region-specific datasets.
- **Poor scalability** when applied across different geographic regions with diverse soil and climate conditions.
- **No integration of real-time data** from IoT sensors (e.g., soil moisture, temperature, humidity).
- **Generalized recommendations** rather than personalized, field-specific predictions.

VI. IMPLEMENTATION

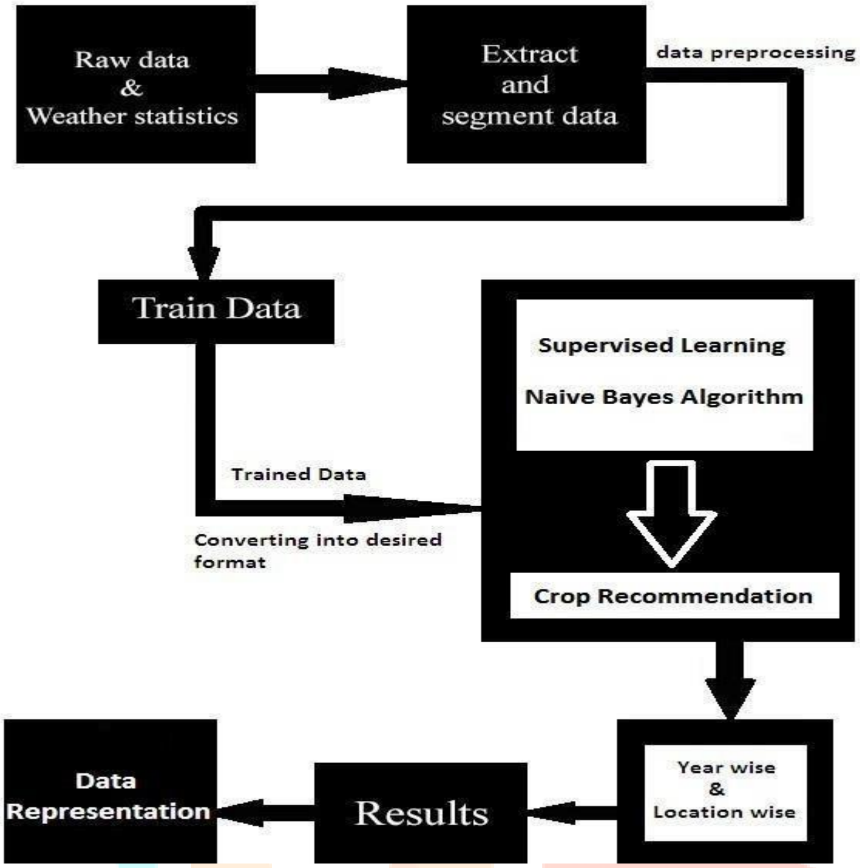


Fig1.1 Block Diagram of crop suggestion

Input – Previous year's agriculture data which includes temperature, rainfall, humidity and other constraints, IOT device used to fetch PH value, N, P K.

Output – predicts suitable crop using different constraints such as region, temperature, rain, humidity based on year wise and location wise and Soil Classification is done.

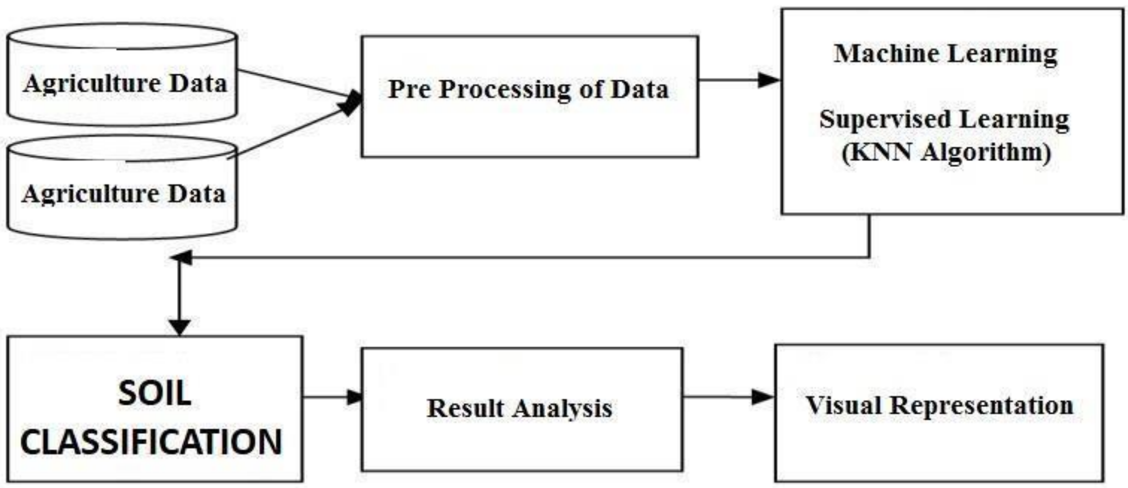


Fig 1.2 Block Diagram of soil classification

- **Raw Data & Weather Statistics**
  - The system begins with **input data** collected from different sources such as soil datasets, agricultural records, and **weather statistics** (temperature, rainfall, humidity, etc.).
  - This raw data is often unstructured and needs to be processed.

 Extract and Segment Data (Data Preprocessing)

- The collected raw data is **extracted and segmented** into useful features such as **soil nutrients (N, P, K), pH, moisture, temperature, and rainfall levels**.
- This step includes **data cleaning, normalization, and feature selection**, preparing it for machine learning algorithms.

 Train Data

- A portion of the dataset is used as **training data** to train the machine learning model.
- The data is converted into the required format (numerical or categorical) so that the algorithm can process it effectively.

 Supervised Learning (Naïve Bayes Algorithm)

- The system applies the **Naïve Bayes classifier**, a supervised learning algorithm.
- This model uses **probability-based classification** to predict the most suitable crop based on soil and climatic conditions.
- It assumes independence between features (like N, P, K, rainfall), making it computationally efficient.

 Crop Recommendation

- Once trained, the model provides **crop recommendations** by analyzing the given input parameters.
- For example: If soil pH is 6.5, Nitrogen is high, rainfall is moderate → Recommend "Wheat".

Year-wise & Location-wise Analysis

- Recommendations are refined further based on **year-wise** (seasonal variations, crop rotation) and **location-wise** (regional climate and soil conditions) analysis.
- This ensures that predictions are **region-specific** and more practical for farmers.

Results & Data Representation

- The final output is represented in a **user-friendly form** (charts, graphs, tables).
- This allows farmers, researchers, or agricultural officers to easily interpret which crop is best suited for a particular soil and climate combination.

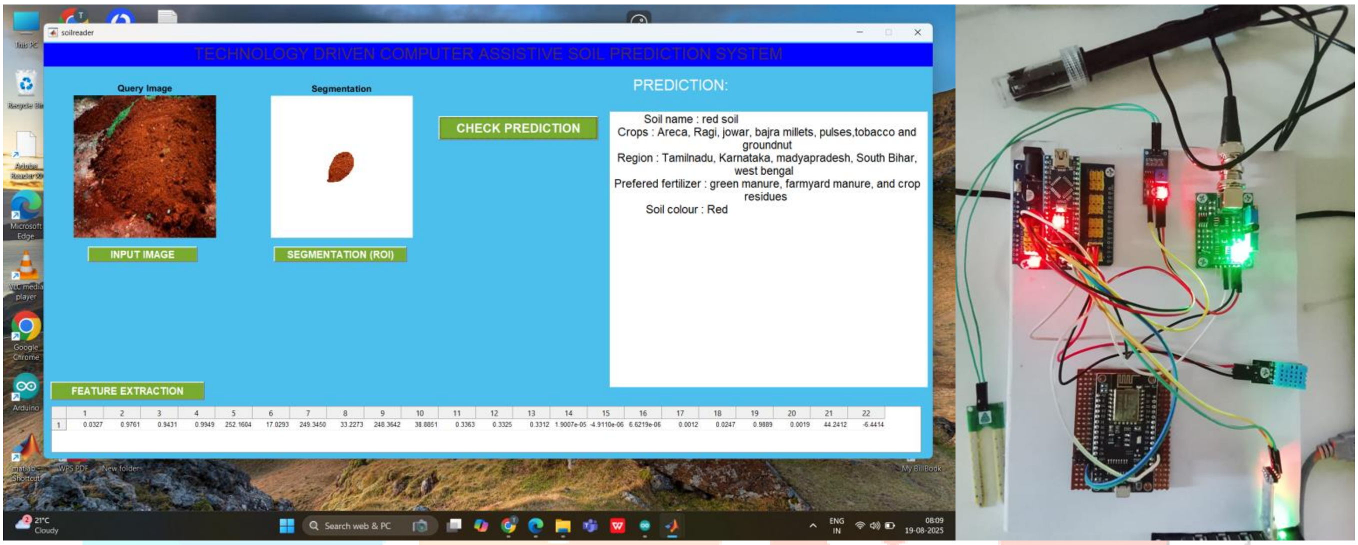


Fig 1.3 soil classification and physical sensor module to detect soil property

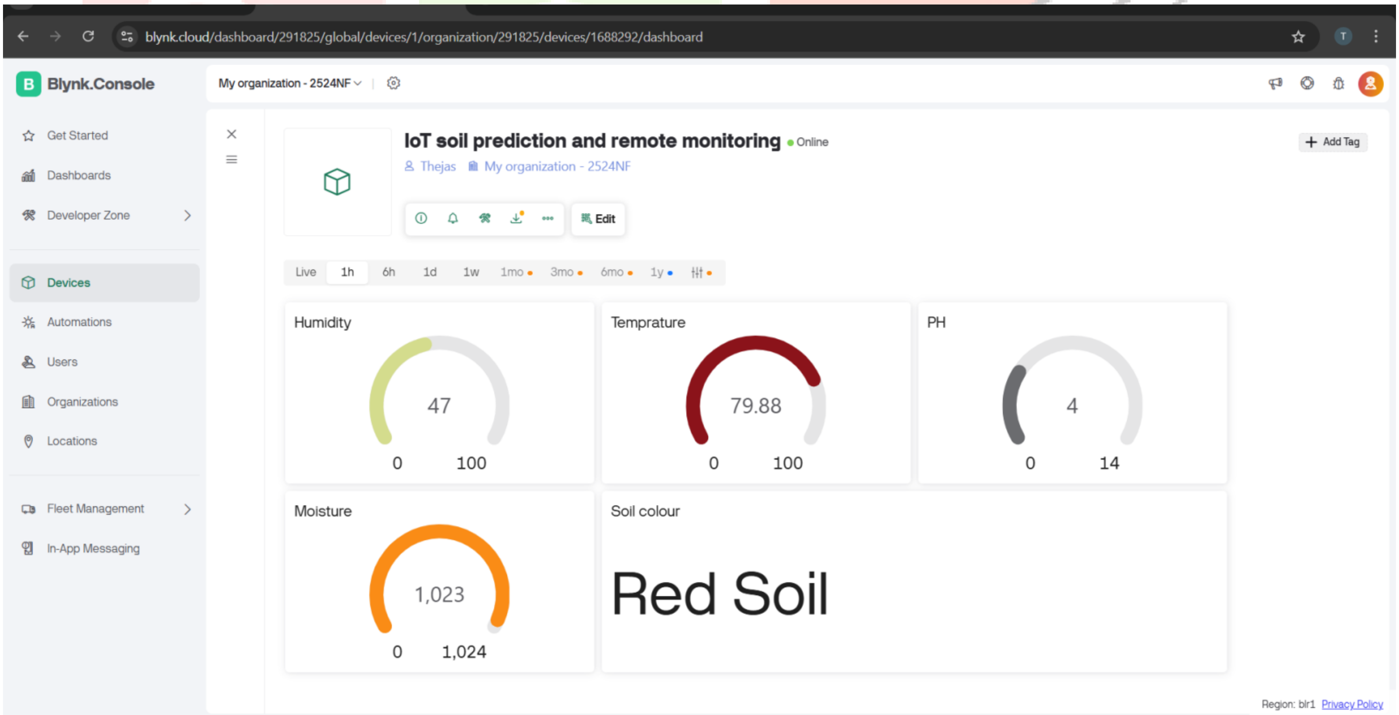


Fig 1.4 Remote data monitoring of soil classification and sensor data

VII. CONCLUSION

A model is proposed for predicting the soil type and suggest a suitable crop that can be cultivated in that soil. The model has been tested using various machine learning algorithms such as kNN, SVM and logistic regression. The accuracy of the present model is maximum than the existing models. In future suitable fertilizers are suggested for the well growth of the crop cultivated. The present models deals with available old data whereas the future model contain the real time a data that is directly received from agricultural land that is placed with sensors. The sensors sense the soil fertility and other minerals contained in the soil.

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