Identification of Fertilizer Based NPL Values and Crop Recommendation Using ML Algorithm

M.Venkatesan[1], M. Neeraja[2], K. Greeshma[3], V. Suneetha[4], S. Avinash Reddy[5], U. Manu Vardhan[6]
[1] Professor, PBR Visvodaya Institute of Technology and Science
[2,3,4,5,6] PBR Visvodaya Institute of Technology and Science

Abstract— FertiForecast is an intelligent system designed to identify the most suitable fertilizer for crops based on soil and environmental parameters using machine learning algorithms. The system integrates a Raspberry Pi with multiple sensors, including an air quality sensor, temperature sensor, soil moisture sensor, pH sensor, and NPK sensor, to continuously monitor essential soil and environmental conditions. These sensor values are transmitted to a machine learning model, which analyzes the data and predicts the appropriate fertilizer needed for optimal crop growth. By leveraging predictive analytics, the system recommends fertilizers tailored to specific crops such as chili (mirchi), groundnut, tomato, and paddy, ensuring efficient nutrient management and improved agricultural productivity. This approach helps farmers make data-driven decisions, enhancing yield quality while minimizing excess fertilizer usage and environmental impact.
Keywords: Fertilizer recommendation, NPK levels, machine learning, Raspberry Pi, pH sensor, air quality monitoring, precision farming.

Index Terms— Precision Agriculture, Machine Learning, Fertilizer recommendation, Soil Nutrient Analysis.

I. INTRODUCTION

Agricultural productivity heavily depends on soil health and the precise application of fertilizers to meet crop-specific nutrient requirements. Traditional fertilizer application methods often lead to overuse or deficiency, affecting crop yield and soil fertility. To address this challenge, FertiForecast integrates modern technology with precision farming by utilizing a Raspberry Pi-based system equipped with multiple sensors, including air quality, temperature, soil moisture, pH, and NPK sensors. These sensors collect data on soil and environmental conditions, which are then processed by Agriculture plays a vital role in feeding the world's growing population. With the increasing demand for food, farmers face the challenge of maximizing crop yields while minimizing environmental impact. Fertilizers are essential in achieving this goal, providing crucial nutrients for plant growth. However, selecting the most suitable machine learning model to analyze nutrient levels and predict the most suitable fertilizer for different crops such as chili (mirchi), groundnut, tomato, and paddy. By leveraging predictive analytics, this system provides farmers with data-driven insights, ensuring optimal fertilizer use, enhancing crop yield, and promoting sustainable agricultural practices while minimizing environmental impact.

Fertilizers play a crucial role in agriculture, providing essential nutrients for crop growth and development. With numerous fertilizer options available, selecting the most suitable fertilizer for a specific crop can be challenging. The NPK (Nitrogen-Phosphorus-Potassium) values of a fertilizer are critical in determining its suitability for a particular crop fertilizer for a specific crop can be a daunting task. Fertilizers are typically characterized by their NPK values, which represent the percentage of Nitrogen (N), Phosphorus (P), and Potassium (K) present in the fertilizer.

Problem Statement

The current process of selecting fertilizers relies heavily on manual methods, such as consulting with agricultural experts or relying on trial and error. This approach can lead to:
1. Inefficient fertilizer usage: Using the wrong fertilizer can result in reduced crop yields, wasted resources, and environmental pollution.
2. Lack of personalized recommendations: Farmers may not receive tailored fertilizer recommendations based on their specific crop, soil, and climate conditions.

Overview

To address these challenges, we propose a machine learning-based approach to identify the most suitable fertilizer for a specific crop based on its NPK values. Our solution will provide personalized fertilizer recommendations, taking into account various factors such as:

1. Crop type: Different crops have unique nutrient requirements.
2. Soil type: Soil characteristics, such as pH and nutrient content, affect fertilizer effectiveness.
3. Climate: Weather conditions, like temperature and rainfall, influence fertilizer application.

The Importance of NPK Values

Fertilizers are typically characterized by their NPK values, which represent the percentage of Nitrogen (N), Phosphorus (P), and Potassium (K) present in the fertilizer. These macronutrients play distinct roles in plant growth:

These macronutrients play distinct roles in plant growth:

1. Nitrogen (N): Promotes leaf growth and development.
2. Phosphorus (P): Essential for root development, flower and fruit formation.
3. Potassium (K): Helps with overall plant health, resistance to disease, and water balance.
4. Crop type: Different crops have unique nutrient requirements.
5. Soil type: Soil characteristics, such as pH and nutrient content, affect fertilizer effectiveness.
6. Climate: Weather conditions, like temperature and rainfall, influence fertilizer application.

II. LITERATURE REVIEW

The application of machine learning (ML) in agriculture has gained significant attention in recent years, particularly in precision agriculture.

Identification of Fertilizer Based on NPK Levels using Machine Learning Algorithms, For many people in India, especially those living in rural areas, agriculture is their main source of income. Approximately 50% of the labour force in the nation is employed by it, either directly or indirectly. Fertilizers play crucial role in modern agriculture by enhancing soil fertility and promoting optimal plant growth. They provide essential nutrients to plants, including nitrogen, phosphorus, potassium, and micronutrients. To boost crop yields, commercial fertilizers are sprayed on agricultural crops.

Identification of Fertilizer Based on NPK Levels using Machine Learning Algorithms, This paper explores the system's design, methodology, and potential impact on the agricultural landscape. [4] [5] Many issues are also reflected in the agriculture industry, like soil degradation, climate change, and the increasing demand for food due to population growth.

Identification of Fertilizer Based on NPK Levels using Machine Learning Algorithms M. Vimaladevi 1, R Thangamani1, Dhivyasubashini K 2, Kandavel G 2, S. Aravind 2, Many Sensors Based Projects for Engineering Students are designed to solve problems in life. Speed checker and Overspeed detection projects also serve the same purpose. Nowadays we hear news about accidents on Highways very frequently. And in most cases, the main reason for accidents is Overspeed. Although all highways do have signboards indicating the maximum speed limit for the sake of driver's safety, still people do not obey the highway speed limit.

Use of Machine Learning and Deep Learning along with NPK Sensor for Intelligent Farming Solutions, The increased human population increases the demand for food. Traditional farming leads to inefficiencies and difficulty in fertilizer usage, crop selection, and insect detection. This research project eliminates all these problems by developing an advanced farming web application to evaluate crop production efficiency. This research evaluates the soil nutrients needed by different plants and thereby generates a recommendation system to recommend the most suitable crop based on sensor values, thus reducing risk, nutritional imbalance and environmental pollution.

Author and Year	Methods	Result
Gosai, Dhruvi et al.[1] 2021	algorithms like Decision Tree, Na¨ıve Bayse	Algorithm Accuracy Decision Tree 90 percent Na¨ıve Bayes 99 percent
Palaniraj et al. [2] 2021	Support Vector Machine	Accuracy of SVM is 90.01 % percent. %
Nischitha K and Dhanush [3] 2020	SVM, Decision Tree	Accuracy of CNN is 81
Shilpa Mangesh Pandey. et al. [4] 2019	Random Forest	Random Forest has 95 percent accuracy.
Sri Rakshitha et al. [5] 2023	Machine Learning, random-forest	enhancing agricultural decision-making.

Sachin Kapoor et al. [6] 2023	Decision Tree.	accuracy obtained by using the ensemble technique is 99.01 percent.
Prof. Maaz Patel et al. [7] 2023	Gaussian Na¨ıve Bayes (GNB)	Accuracy of the great with 99.3 percent. % to 96 %. depends on the system's hardware specifications.
Vincent Boubie et al. [8] 2018	Random Forest and SVM.	Random Forest showed the best% results with 95% accuracy.% very active.
A. Barman et al. [9] 2022	svm, random forest.	enhances crop yields and sustainability in diverse cropping patterns, as demonstrated in the study published in Bangladesh 2019
Patten [10] 2015	Machine Learning, random forest, SVM	The accuracy ob-tained by using the ensemble technique is 99.01 percent. %

III. PROPOSED SYSTEM

The proposed method integrates IoT sensors with machine learning to deliver precise and real-time crop recommendations. A Raspberry Pi microcontroller is used to collect data from a range of sensors, including a pH sensor, soil moisture sensor, LDR for light intensity, MQ135 for air quality, and DHT11 for temperature and humidity. This data is processed using the Random Forest algorithm as part of a Voting Ensemble model, which combines multiple machine learning algorithms to enhance prediction accuracy. The system analyzes the collected environmental and soil data, then provides crop recommendations based on real-time conditions. Results are displayed on an LCD screen, allowing farmers to make informed decisions quickly. This approach automates the process, reduces the reliance on manual input, and ensures more accurate, personalized crop recommendations, improving yield and resource management efficiency.

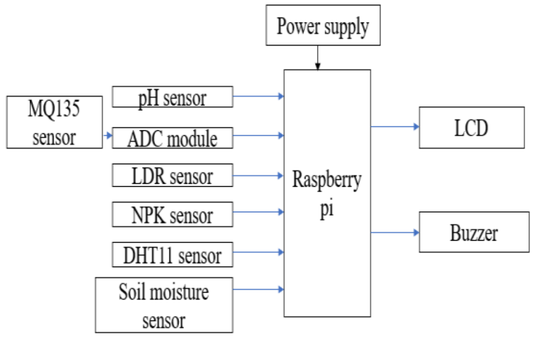

Fig : Block diagram of the Proposed System

The proposed system uses machine learning (ML) algorithms to identify suitable fertilizers based on soil NPK (Nitrogen, Phosphorus, Potassium) values and recommend crops accordingly.
1. NPK Sensor/Data Collection: Collecting soil NPK data through sensors or manual input.
2. Crop Database: Storing information on various crops, including their NPK requirements.
3. Fertilizer Database: Storing information on different fertilizers, including their NPK composition.
4. ML Model: Training ML algorithms to predict suitable fertilizers and crops based on NPK analysis.
Workflow
1. Soil NPK Analysis: Analyzing soil NPK values to determine nutrient deficiencies.
2. Crop Selection: Selecting a crop or recommending suitable crops based on soil NPK values.
3. Fertilizer Recommendation: Predicting suitable fertilizers based on NPK analysis and crop requirements.

Data Collection:
Details: Data Collection: • Details:"The dataset includes variables such as humidity, temperature, rainfall, and the concentrations of nitrogen (N), phosphorus (P), potassium (K), and other elements. The Kaggle website is where the datasets were found. The data set contains 2200 instances of data that were obtained from historical data in the past. Rice, maize, chickpeas, kidney beans, pigeonpeas, mothbeans, mungbeans, blackgram, lentil, pomegranate, banana, mango, grapes, watermelon, muskmelon, apple, orange, papaya, coconut, cotton, jute, and coffee are among the eleven different crops included in this dataset.

Feature Extraction:
Details: Feature extraction is essential to improving the precision and applicabil- ity of our predictions in

our machine learning research for crop and fertilizer recommendation. Among these characteristics are soil characteristics like pH values, nutrient concentrations (nitrogen, phosphorus, and potassium), moisture content, temperature, and climate information including rainfall patterns and temperature swings. – We use a variety of methodologies, including statistical techniques and Principal Component Analysis (PCA), to ensure thorough feature extraction. We can effectively process and analyze the dataset by using PCA to minimize the dataset's dimensionality while preserving important data. – We can find connections and trends by examining past crop yields combined with soil and weather variables, allowing for precise forecasting.In order to identify the most important features, our feature extraction approach also incorporates.

machine learning algorithms, especially XGBoost and Random Forest. – Utilizing these cutting- edge techniques, we make sure that our model is trained on the most pertinent and significant features, increasing its accuracy in suggesting suitable crops and optimizing fertilizer formulations. This thorough feature extraction strategy is essential to the accomplishment of our project. – We find subtle patterns using machine learning approaches that might not be visible through conventional analysis. This comprehensive approach makes sure that our recommendations are based on both the crop's long-term viability and the current soil conditions.

Real Time Analysis:

An ML algorithm is Random Forest. Numerous decision trees are created during the training phase, and the result is then separated into classification and regression outputs depending on the number of classes. The accuracy of the forecast increases with the number of trees

Exercise Correction:

Pre-processing is necessary for a successful application. The information obtained from many sources is occasionally in raw form. It might include some conflicting, redundant, or incomplete data. Therefore, such redundant data needs to be filtered in this step. Information should be standardized.

These algorithms cooperate as a part of a bigger system in this project. You can feed pose data (extracted from exercise videos using MediaPipe Pose [7] or OpenPose [?]) into your GCN [11] and LSTM [?] layers based motion correction model. The model will assess the data and deliver real-time feedback using Proximity-Based Correction [9], driven by BN [?], ReLU [4], and Dropout [?].

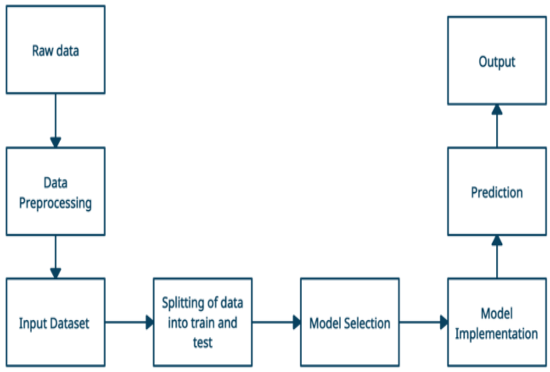

Figure 1. Block Diagram of Crop recommendation Model

IV. RESULT

Displaying results on screen is a critical aspect of any fertilizer and crop recommendation system. By considering key factors such as user-friendly interface, visualizations, fertilizer and crop recommendations, confidence level, comparison with other options, additional information, and alerts and warnings, developers can create a system that provides accurate and actionable recommendations to farmers. The example provided demonstrates how these factors can be effectively displayed on screen, enabling farmers to make informed decisions about fertilizer application and crop selection. By leveraging this technology, farmers can optimize crop yields, reduce waste, and promote sustainable agricultural practices.

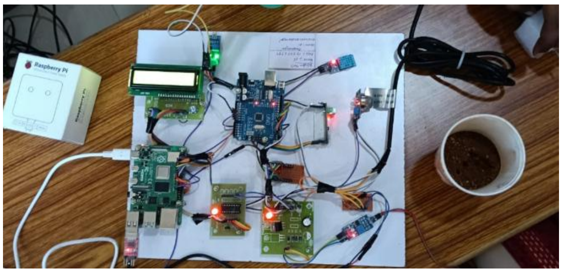

Fig: Circuit connection

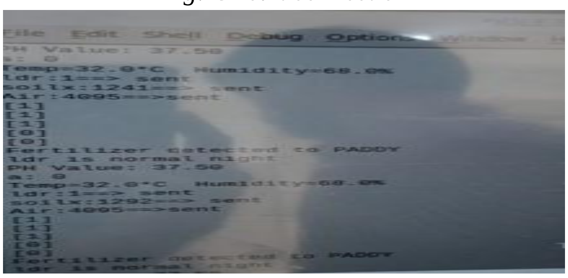

Fig: Display the Result on Screen

V. CONCLUSION

The identification of fertilizers based on their NPK values using machine learning algorithms has proven to be an effective and efficient approach for optimizing agricultural practices. By leveraging the power of data-driven methodologies, we have demonstrated that machine learning can accurately classify fertilizers based on their nutrient composition, aiding in precise nutrient management and soil fertility enhancement.

In conclusion, the application of machine learning algorithms for fertilizer identification based on NPK values represents a significant advancement in agricultural technology. By enabling precise and data-driven fertilizer recommendations, this approach contributes to improving soil health, optimizing crop growth, and promoting environmentally sustainable farming practices. Future developments in this field, including the integration of IoT-based soil sensors and AI-driven recommendation systems, hold great potential for revolutionizing modern agriculture and ensuring food security for a growing global population.

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