Soil Health Monitoring System for Farming

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Abstract— The effective management of nutrient resources in agricultural practices is crucial for crop yields optimization and sustainable farming assurance. Traditionally, manual methods or expert knowledge have been relied on by farmers to determine the appropriate amount and type of nutrients required by crops. However, precision is often lacking in these methods and suboptimal fertilization can be resulted in, leading to reduced productivity and environmental degradation. In recent years, the way has been paved for more accurate and efficient crop management systems by advancements in sensor technology. One such innovation is the NPK sensor, which allows real-time monitoring of soil nutrient levels. Personalized fertilization recommendations are offered to farmers by our proposed system utilizing NPK sensor data. Precise and tailored nutrient recommendations are provided by the system, integrating sensor technology, machine learning algorithms, and agronomic expertise, based on the specific requirements of different crops and soil conditions. Data, including soil nutrient levels, is collected from NPK sensors deployed in the field by the system. This data is analyzed by machine learning algorithms to identify patterns and correlations between nutrient levels and crop performance. The system can generate accurate and timely recommendations for nutrient application by leveraging historical data and agronomic knowledge.

Index Terms—Agriculture, Crops, Crop Yield Prediction, Farming, Machine Learning

I. INTRODUCTION

The aim of the proposed paper is to develop a crop recommendation system using information from NPK sensors. To find out more about the nutritional composition of the soil, sensor data from NPK (nitrogen, phosphorus, and potassium) sensors will be used by the system. Machine learning algorithms will be used to utilize this data to recommend crops that are likely to flourish in the specific soil conditions. To achieve this goal, several essential steps will need to be taken by the paper. Data collecting is the initial stage to train and test the model. Utilizing the current dataset allows for this. This stage could also involve dealing with missing numbers, removing outliers, and normalizing to ensure the accuracy and consistency of the data. The pre-processed and selected features will then be utilized to build a crop recommendation model using machine learning techniques. Patterns and links between those outcomes and the nutrient level of the soil will be identified by these algorithms as they follow the success of different crops. Crops that are most suited for a particular field considering the composition of the soil's nutrients will be recommended by the model. A lot of promise for assisting farmers and agricultural researchers is held by the suggested strategy. Crop recommendations based on information on soil nutrients can help farmers choose crops that are more likely to thrive and yield superior outcomes. Agricultural output could be increased and crop failure reduced due to nutrient deficiencies in the soil. The current paper also provides a great opportunity to learn about and gain expertise with data processing, feature selection, and machine learning approaches. The techniques can be utilized in the field of agriculture to boost crop production and assist in resolving issues that affect farmers and the industry.

II. LITERATURE SURVEY

[1] A cloud-enabled crop recommendation software for machine learning-driven precision farming was utilized by Navod Neranjan Thilakarathne, Muhammad Saifullah Abu Bakar, Pg Emerolyariffion Abas, and Hayati Yassin to make informed decisions on the farms. Machine learning, a subfield of artificial intelligence (AI), is employed to assist people in learning from their experience and afterwards recommending crops. The data sets were split into training and testing sets at a ratio of 70:30. This was done using the Random Forest classifier, resulting in an accuracy of 87.23%.

[2] Crop recommendation on soil analysis was conducted using machine learning by Anguraj. K, Thiyaneswaran. B, Megashree. G, Preetha Shri. J. G, Navya. S, and Jayanthi. J. Here, an IoT system was employed to collect real-time data, which was then

used to train a model and make predictions. The output of the model significantly aids in planting the right crops in certain field locations. An accuracy of about 80.34% was achieved with the development of this technique.

[3] R. Pallavi Reddy, B. Vinitha, K. Rishitha, and K. Pranavi created crop monitoring and recommendation systems utilizing machine learning and IoT. Sensors are utilized to gather the data, which is then delivered to NodeMCU, an android app used to train the model and subsequently make predictions. The algorithm utilized in this system, together with key elements like sensors and an Arduino, is used to create the modules. The system created offers appropriate advice and is user-friendly.

[4] A crop recommendation and yield forecast for agriculture were created by Aakunuri Manjula and Dr. G. Narsimha using data mining techniques. Data collection, feature selection, employing classification techniques, and crop suggestion using ensembling algorithms constitute all steps in the methodology. The use of data mining techniques constrained the system's accuracy and precision.

[5] Machine learning was utilized by Mahendra Choudhary, Rohit Sartandel, Anish Arun, and Leena to produce a crop recommendation system and plant disease classification for precision agriculture. The technique of the system includes the classification of agricultural diseases and the phases of collecting, exploration, splitting, and implementation. A 60:20:20 ratio was utilized by them to divide the primary dataset into the training dataset, validation dataset, and testing datasets. The Random Forest Classifier was employed by them for predicting the crops.

III. METHODOLOGY

Two phases and several sub-phases mainly constitute the proposed methodology. Nutrient values from soil are read in the first phase. Crop recommendations are given by the developed model in the second phase of the methodology using the values obtained from the soil.

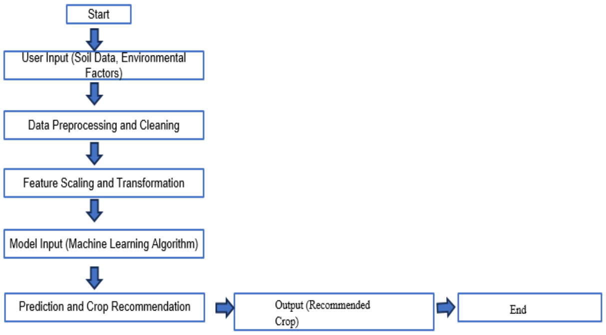


Fig. 1. Block Diagram for crop recommendation

A. Hardware Components

The three main components required for system development are the Arduino Nano board, NPK sensor, and MAX485 module. The Arduino Nano is called a popular microcontroller board based on the Atmega328P microcontroller. The board has 6 analog input pins, 6 PWM output pins, and 14 digital input/output pins, including 6 that can be used as PWM outputs. Both 3.3V and 5V logic levels are supported via the I/O pins, which are used by the board to function at 5V. The Arduino board can be connected to a computer for programming and communication using its built-in USB port. When seen on a PC, it appears as a virtual COM port. A hardware serial port is contained within the board to communicate serially with external devices using the USB interface.

Fig. 2. Arduino Nano Board

An NPK sensor is used to measure nitrogen, phosphorus, and potassium, three crucial elements in soil. Commercial fertilizers frequently contain these essential nutrients, which are necessary for plant growth. NPK sensors examine the electrical conductivity or spectral characteristics of the soil to ascertain nutrient contents.

Soil-based probes, often comprising the sensor, can monitor NPK levels in real time or very close to real time. A variety of configurations are available for NPK sensors, including portable units, handheld devices, and even integrated systems that can be mounted on agricultural equipment for automated soil analysis. The brown wire represents the VCC pin, which is connected to the 5v-30v power supply. A yellow-colored wire connects the differential signal to the A pin of the MAX485 Modbus Module. The B pin of the MAX485 Modbus Module is linked to another differential signal, B (blue wire).The black wire, labeled GND, designates the Ground pin.

Fig. 3. NPK Sensor

A two-way communication between devices that use TTL-level signals and those that use RS485 signals is enabled by the MAX485 module. The foundation of the MAX485 module is the MAX485 integrated circuit, a low-power transceiver for RS485 and RS422 communication. A half-duplex communication that converts TTL level signals into differential voltage signaling RS485-level signals is supported by the module. Longer-distance communication with improved noise immunity is enabled by this feature. Development boards and microcontrollers that operate in the 3.3V to 5.5V supply voltage range are normally compatible with this module.

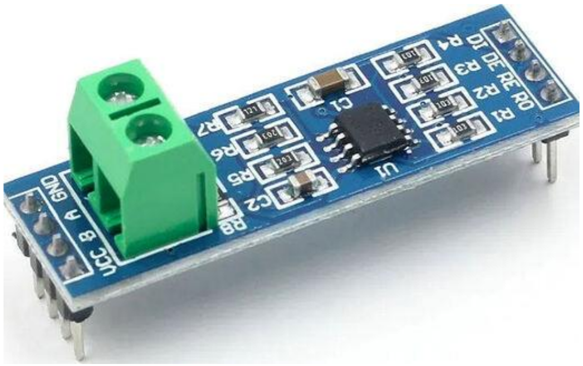


Fig. 4. RS-485 Interface Module

B. Random Forest

Random Forest, a popular machine learning algorithm, belongs to the supervised learning technique. Both classification and regression problems in machine learning can be addressed using Random Forest. The concept of ensemble learning, which involves combining multiple classifiers to solve a complex problem and improve the performance of the model, is the basis of Random Forest. As the name suggests, *"Random Forest is a classifier that contains a number of decision trees on various subsets of the given dataset and takes the average to improve the predictive accuracy of that dataset."* Instead of relying on one decision tree, the prediction from each tree is taken by the random forest, and based on the majority votes of predictions, the final output is predicted. A higher number of trees in the forest leads to higher accuracy and prevents the problem of overfitting.

Below are some points that explain why the Random Forest algorithm should be used:

- Less training time is taken by it as compared to other algorithms.
- Output is predicted with high accuracy, even for large datasets it runs efficiently.
- Accuracy can also be maintained when a large proportion of data is missing.

Random Forest works in two phases: first is the creation of the random forest by combining N decision trees, and the second is making predictions for each tree created in the first phase. The working process can be explained in the following steps:

Step 1: Randomly select K data points from the training set.

Step 3: Choose the number N for decision trees that you want to build.

Step 4: Repeat Steps 1 and 2.

Step 5: For new data points, find the predictions of each decision tree, and assign the new data points to the category that wins the majority votes

C. Working

To read nutrient values from the soil initially, you need to interface the NPK sensor with the Arduino board. Figure shows the semantic diagram for interfacing between the hardware components.

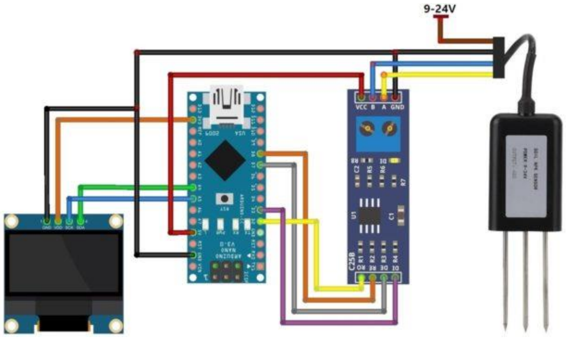
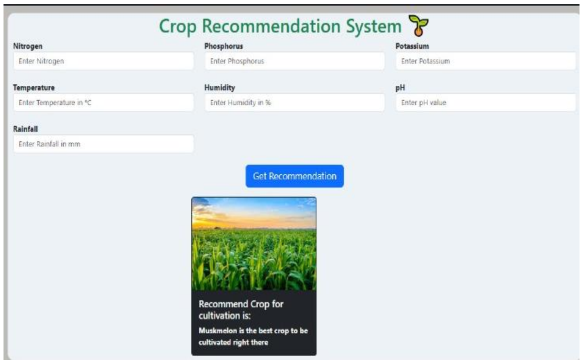


Fig. 5. Arduino – NPK Sensor Interfacing

- The NPK sensor, having four wires, requires the attachment of the brown power line to the 5V-30V power supply, and the black ground wire to a common ground.
- The yellow wire of the NPK sensor should be connected to the RS485 module's A pin, and the blue wire should be connected to the B pin.
- Connect the digital pins 2 and 3 of the Arduino to the RS485 module's R0 and DI pins.
- Link the DE and RE pins to digital pins 7 and 8, respectively, and connect the VCC pin of the RS485 module to the Arduino's 5V output.
- Finally, ensure that the Arduino and the circuit share a common ground.

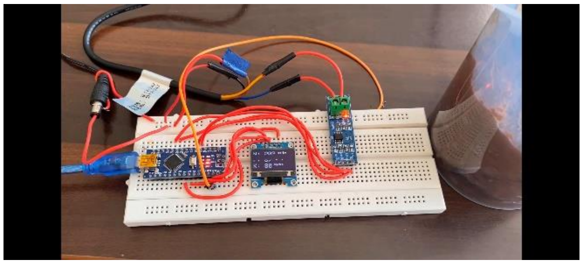
IV. RESULTS

Upon providing the soil nutrient values obtained using the NPK sensor, the system displays the recommendation of the suitable crop. Nitrogen, phosphorus, and potassium values from the soil are taken by the proposed system, and the crop that is best suitable for the soil is recommended, as shown in the figure.


Crop Recommendation System

Recommend Crop for cultivation is:

Muskmelon is the best crop to be cultivated right there



CONCLUSION

According to our research, crop recommendation systems with NPK sensors play a crucial role in changing the agricultural industry. The Crop Recommendation System described in this work is an example of how urgent problems of feeding a growing global population while minimizing environmental effects can be tackled by data-driven solutions. Farmers are helped by the system to implement precision agriculture practices, resulting in sustainable and resource-efficient crop cultivation, by offering tailored crop suggestions based on real-time NPK data.

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