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IoT-Enabled Device for Effective Crop Yielding using Deep Learning Techniques

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ABSTRACT

The agriculture sector, including India, plays a critical role in the economy of many countries. However, farmers face various challenges such as uncertainty in crop yields, pest and disease infestations, water scarcity, and lack of knowledge in crop management. Recent advances in technology such as Deep Learning and IoT have the potential to revolutionize the way farmers manage their crops. By using Deep Learning algorithms, farmers can identify plant diseases accurately, which is crucial for disease control and prevention. The use of sensors to detect environmental factors such as temperature, humidity, soil moisture, and nutrient levels can provide real-time monitoring of fields. Analyzing this data using machine learning techniques can optimize crop growth and yield. For example, smart irrigation systems can be developed to ensure that crops receive the right amount of water based on the moisture content of the soil. This approach can help reduce water usage and increase crop yield. Data analytics can also help farmers identify the best crop to grow in a particular location based on environmental conditions, soil quality, and market demand. This approach can help farmers make informed decisions about crop selection and maximize their profits. In summary, the combination of Deep Learning and IoT has the potential to transform the agriculture sector by providing farmers with real-time information on crop growth, disease control, and environmental conditions. This approach can help farmers increase crop yields, reduce water usage, and make informed decisions about crop management.

*KEYWORDS: **Precisionagriculture, crop recommendation, Efficient Net model, Resnet model, CNN, Disease Identification, Soil Values, Environmental Factors, Logistic Regression**.*

1. INTRODUCTION

India is a major producer of agricultural products, but the country's farm productivity remains low. Precision agriculture offers a solution to increase productivity and yield by applying precise amounts of fertilizers, water, and other inputs at the right time. However, not all precision agriculture systems are effective and accuracy is crucial to avoid material and capital loss. Machine learning techniques, including ensembling and the voting method, are being used to build accurate models for crop prediction. This paper proposes an efficient and accurate model for crop prediction using the voting method in precision agriculture research. In addition, the use of IoT sensors can provide real-time data on various environmental factors such as temperature, humidity, soil moisture, and nutrient levels. This data can be used to make informed decisions on crop management, irrigation, and fertilization. The combination of precision agriculture techniques and IoT sensors can help farmers increase crop productivity and yield while reducing the use of resources and minimizing environmental impact. Overall, precision agriculture and the use of machine learning algorithms and IoT sensors have the potential to revolutionize the agricultural sector in India and help farmers increase their income and improve their standard of living.

The agriculture sector, including India, plays a critical role in the economy of many countries. However, farmers face various challenges such as uncertainty in crop yields, pest and disease infestations, water scarcity, and lack of knowledge in crop management. Recent advances in technology such as Deep Learning and IoT have the potential to revolutionize the way farmers manage their crops.

2. LITERATURE SURVEY

Crop Recommendation

Crop Yield Prediction Using Machine Learning Techniques: A Review" by S. Sujatha etal. (2020): This review paper presents an overview of machine learning techniques used for crop yield prediction. It includes a discussion of various data sources, such as soil properties, climate, and crop management practices, and the different types of models used, including regression models, decision trees, and neural networks. The authors also highlight the challenges associated with these models and suggest future research directions [1].

"A Review on Crop Recommendation System Using Machine Learning Techniques" by M. A. Hossain et al. (2021): This paper provides a comprehensive review of crop recommendation systems that use machine learning techniques. It discusses the different types of data used, such as climate, soil, and crop information, and the various machine learning algorithms used for recommendation systems, including decision trees, support vector machines, and deep learning models. The authors also discuss the benefits and limitations of these systems and suggest future research directions [2].

"Crop Recommendation System using Deep Learning Techniques" by A. N. Kanade et al. (2020): This paper presents a crop recommendation system using deep learning techniques. The authors collected data on soil properties, climate patterns, and crop characteristics for a particular region and used a convolutional neural network (CNN) to recommend crops. The authors reported that the CNN-based model showed better accuracy compared to other machine-learning techniques such as decision trees and support vector machines. The authors also suggested future research directions for improving the efficiency and scalability of the deep learning-based crop recommendation system [3].

Plant Disease Detection Using Deep Learning

"Plant Disease Detection Using Deep Learning: A Review" by Priya Singh and Avneesh Kumar. This paper provides an overview of the application of deep learning techniques for plant disease detection, including a discussion of different datasets and methods used [1].

"A Survey on Plant Recognition Techniques Using Deep Learning" by Sagar Rajput, Avinash Kesari, and Vinod Tiwari. This paper provides a comprehensive survey of deep learning techniques for plant recognition, including plant identification, classification, and segmentation [2].

"Plant Species Identification Using Deep Learning Techniques" by Ahmadreza Shahriari, Amin Hashemi, and Mohammadreza Faraji. This paper proposes a deep learning-based approach for plant species identification using leaf images, including a discussion of the dataset used and the performance of the method [3]

3. METHODOLOGY

DATASETCOLLECTION

The data was gathered via Kaggle, a well-known website for discovering datasets relating to many different fields, including agriculture. The platform provides a wide range of datasets, including features particular to the soil and general crop data, that may be used to identify diseases and recommend crops.

This dataset takes into account the following characteristics: temperature, humidity, pH, nitrogen, phosphorous, and potassium. These factors are essential to the development and health of crops because they determine the soil's capacity to offer the right conditions for the plants to absorb nutrients and water. Nitrogen (N), phosphorus (P), and potassium (K) are important for vegetative development in stems, early-stage root growth, seed and flower creation, bud growth, and fruit ripening. NPK fertilizer supplies all the critical elements needed by the plant. There may be three or more possible unordered kinds of the dependent variable in multinomial logistic regression, such as "crops."

Groundnut, cotton, vegetables, bananas, paddy, sugarcane, and coriander are among the crops taken into account in this dataset. and features a thorough gallery of pictures of both healthy and ill plants for a variety of crops, including tomatoes, potatoes, grapes, apples, oranges, and many others. These pictures were compiled from several sources. According to the ailment that is present, each image has been named, along with thorough descriptions of the symptoms and predict the diseases. There are a predetermined number of instances of each crop in the training dataset. This dataset can be used to identify diseases and make recommendations for crops.

Crop Prediction using EfficientNetV2

EfficientNetV2 is a promising deep-learning architecture for crop recommendation systems. Its superior performance and efficiency make it a great choice for analyzing large amounts of data related to soil moisture, nitrogen, phosphorus, rainfall, temperature, humidity, and other environmental factors relevant to crop growth.

By fine-tuning the EfficientNetV2 model on crop-related datasets, it is possible to create a highly accurate and customized crop recommendation system. The model can be trained to identify patterns in the environmental data and suggest multiple crops that are best suited for a specific region or growing condition.

EfficientNetV2 can also be used in conjunction with other techniques such as transfer learning and data augmentation to improve the accuracy and robustness of the recommendation system. With its ability to scale to different image sizes and input dimensions, EfficientNetV2 is well-suited for handling large amounts of data related to crops, which is critical for accurate and reliable recommendations.

Overall, the use of EfficientNetV2 in crop recommendation systems can significantly improve the efficiency and accuracy of crop selection, leading to higher yields and improved crop quality.

4. MACHINE LEARNING METHODS EMPLOYED MODEL DEVELOPMENT

Logistic Regression

Logistic regression is a statistical technique used to model the probability of a certain event occurring. In crop recommendation, logistic regression can be used to predict the probability of a certain crop growing well in a particular location based on environmental factors such as temperature, soil type, NPK, rainfall, and other relevant parameters.

The use of logistic regression in crop recommendation has several advantages. First, it can help farmers make more informed decisions about which crops to grow in a particular location, which can help to increase their yields and profits. Second, it can help to reduce the risk of crop failure due to unfavorable environmental conditions. The environmental factors data can be used to train a logistic regression model to predict the probability of a certain crop growing well in a particular location. Once the model is trained, farmers can use it to make informed decisions about which crops to grow in a particular location based on the predicted probability of success.

For example, if the model predicts a high probability of success for a certain crop in a particular location, farmers may choose to plant that crop in that location to maximize their chances of a successful harvest.

Convolutional Neural Network

Convolutional Neural Network (CNN) algorithms are widely used for identifying leaf diseases in plants. This is because CNNs are well-suited for image recognition tasks, and identifying leaf diseases involves analyzing images of the leaves.The process of using a CNN for identifying leaf diseases typically involves several steps. First, a dataset of images of healthy and diseased leaves is collected and labeled. The images may be captured using cameras or other sensors attached to drones, smartphones, or other devices. Next, the dataset is split into a training set and a testing set. The training set is used to train the CNN to recognize the different types of leaves and diseases, while the testing set is used to evaluate the performance of the CNN.

The CNN is typically trained using a series of convolutional layers, pooling layers, and fully connected layers. The convolutional layers extract features from the images, while the pooling layers reduce the size of the features to make the network more efficient. The fully connected layers perform the classification task by outputting a probability score for each class (i.e., healthy or diseased).Once the CNN is trained, it can be used to identify leaf diseases in new images. This involves passing the image through the CNN and evaluating the output probabilities. The class with the highest probability is then assigned to the image.

Overall, CNN algorithms are a powerful tool for identifying leaf diseases in plants. They have the potential to improve the accuracy and efficiency of disease detection, which can help to prevent the spread of diseases and improve crop yields.

Some Images from training dataset:
Tomato___Late_blight', 'Tomato___healthy', 'Grape___healthy', 'Orange___Haunglongbing_(Citrus_greening)', 'Soybean___healthy', 'Squash___Powdery_mildew', 'Potato___healthy', 'Corn_(maize)___Northern_Leaf_Blight', 'Tomato___Early_blight', 'Tomato___Septoria_leaf_spot', 'Corn_(maize)___Cercospora_leaf_spot Gray_leaf_spot', 'Strawberry___Leaf_scorch', 'Peach___healthy', Apple___Apple_scab', 'Tomato___Tomato_Yellow_Leaf_Curl_Virus', 'Tomato___Bacterial_spot', 'Apple___Black_rot', 'Blueberry___healthy'.
These are the names of the diseases in the dataset. Which are some common plant diseases that can cause significant damage to crop.

ResNet Model in Convolutional Neural Network

ResNet (Residual Network) is a powerful CNN architecture that has been used in disease identification and for finding solutions to various plant diseases. ResNet is particularly useful in this context because it is able to learn more complex features and patterns in images, making it ideal for detecting accurate differences between healthy and diseased plants. In plant disease identification, ResNet can be trained on a dataset of images that include healthy plants and plants with various diseases.

The ResNet model can then learn to recognize the features and patterns associated with each disease, allowing it to accurately identify the presence of disease in new images. Once the disease has been identified, ResNet can also be used to find solutions for treating or preventing the disease. For example, if a plant is found to have a specific disease, ResNet can be used to suggest the best treatment or prevention strategy based on previous data and research. Overall, ResNet is a powerful tool for identifying plant diseases and finding solutions for these diseases.

It has the potential to improve crop yields and prevent the spread of plant diseases, which can have a significant impact on agriculture and food production.

Implementation of Project

Device Management and Communication Protocols with Application

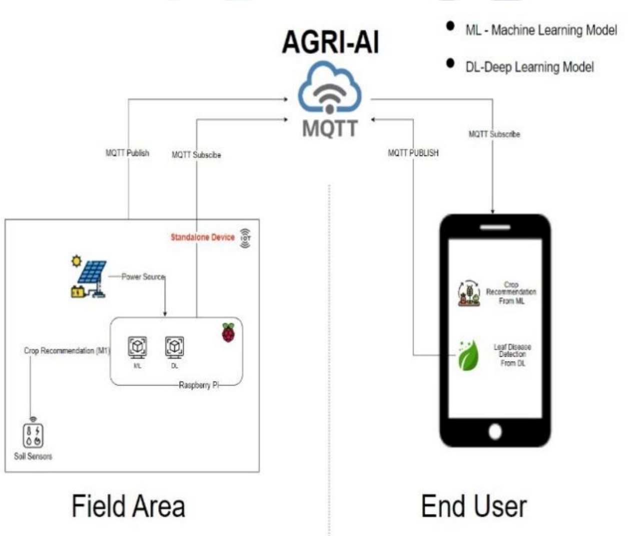

Fig.1 Architecture of the proposed solution.

RulesinducedfromtheModel

The rule below demonstrates an example of the proposedrecommendationsystem.

If pH is 5.8 Acidic AND
Temperature is below 26 AND
Rainfall is around 90ml AND
NPK values are 94:15:19 AND
Humidity is average 73 AND
Soil quality is LOW
THEN

Crop is MAIZE

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Analysis of Developed Application:

- **Leaf Diseases UI**

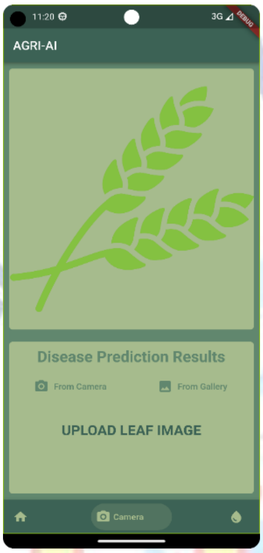


Fig.2 Leaf Disease UI

- **Leaf Disease Detection**

Fig.3 Leaf Disease Detection

To get started, you can either select an image of a leaf from your gallery or take a photo directly using your camera. Our advanced image recognition technology will then analyze the leaf and provide you with information such as the type of disease the plant has.

Here Late blight is caused by the oomycete Phytophthora infestans. Oomycetes are fungus-like organisms also called water molds. but they are not true fungi. There are many different strains of P. infestans. These are called clonal lineages and are designated by a number code (i.e. US-23). Many clonal lineages affect both tomatoes and potatoes. but some lineages are specific to one host or the other. Late blight is a potentially devastating disease of tomatoes and potatoes. infecting leaves. stems and fruits of tomato plants. The disease spreads quickly in fields and can result in total crop failure if untreated. Late blight of potato was responsible for the Irish potato famine of the late 1840s.'

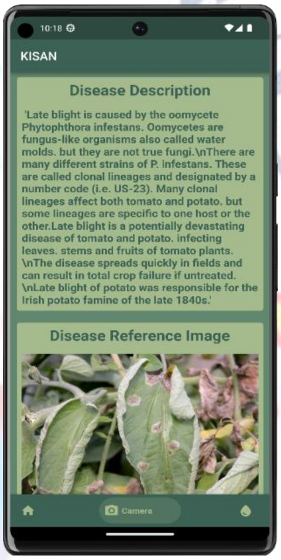


Fig.4

Once an image is selected, the app will identify the disease affecting the plant and provide a corresponding prediction.

- **Procedure to follow for Prevention:**

Sanitation is the first step in controlling tomato late blight. Clean up all debris and fallen fruit from the garden area. This is particularly essential in warmer areas where extended freezing is unlikely and the late blight tomato disease may overwinter in the fallen fruit. Currently. there are no strains of tomato available that are resistant to late tomato blight. so plants should be inspected at least twice a week. Since late blight symptoms are more likely to occur during wet conditions. more care should be taken during those times. For the home gardener. fungicides that contain maneb. mancozeb. chlorothalonil or fixed copper can help protect plants from late tomato blight. Repeated applications are necessary throughout the growing season as the disease can strike at any time. For organic gardeners. there are some fixed copper products approved for use; otherwise. all infected plants must be immediately removed and destroyed.'

Fig.5

- **Supplement:**

Fig.6

- **Crop Recommendation**

This app uses advanced algorithms to suggest multiple crops that can be grown based on the environmental factors of your region. It takes inputs from the relevant sensors to gather information about soil moisture, nitrogen, phosphorus, rainfall, potassium, temperature, and humidity. And analyzes this data and suggests multiple crops that are suitable for your area.

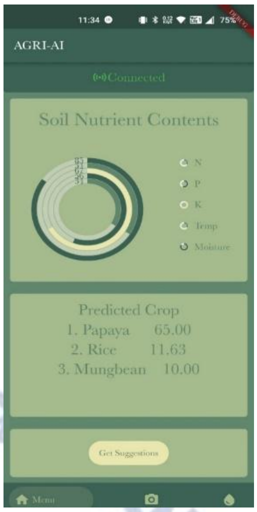


Fig.7

Required Components

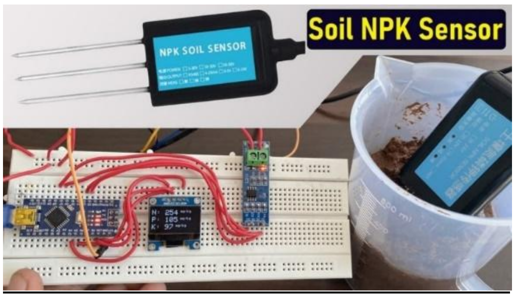
<u>RASPBERRY PI</u>

Raspberry Pi is a small single-board computer. By connecting peripherals like a Keyboard, mouse, and display to the Raspberry Pi, it will act as a mini personal computer.

Raspberry Pi is popularly used for real-time Image/Video Processing, IoT-based applications, and Robotics applications. Raspberry Pi is slower than a laptop or desktop but is still a computer that can provide all the expected features or abilities, at low power consumption.

<u>NPK Sensor:</u>

The soil nutrient content can be easily measured using NPK Soil Sensor & Arduino. Measurement of soil content N (nitrogen), P (phosphorus), and K (potassium) is necessary to determine how much additional nutrient content is to be added to soil to increase crop fertility. The soil fertility is detected using NPK sensors. The major component of soil fertilizer is nitrogen, phosphorus, and potassium. The knowledge of the soil nutrient concentration can help us to learn about nutritional deficiency or abundance in soils used to endorse plant production.



EC Sensor:

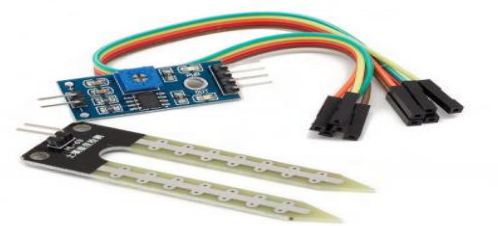
Soil EC Sensor JXBS-3001-EC-I20-4 is a high functional and digital display soil meter. Agricultural sensor series products are widely used in agricultural greenhouses, flower cultivation, pasture grassland and other occasions, real-time monitoring of temperature and humidity, light care, soil and other conditions, including temperature and humidity sensors, soil conductivity (EC) sensors, illuminance sensors, and other types All-in-one sensor.

PH Sensor:

pH Sensor is a low cost, high precision analog PH measurement module. It can work with 3.3V and 5V. With the help grove connector and BNC probe interface. You can easily connect with your control board like Arduino or Raspberry pi and get the PH value.

Soil Moisture Sensor:

Soil moisture sensors measure the volumetric water content in soil. Since the direct gravimetric measurement of free soil moisture requires removing, drying, and weighing of a sample, soil moisturesensors measure the volumetric water content indirectly by using some other property of the soil, such as electrical resistance, as a proxy for the moisture content.



Arduino Nano:

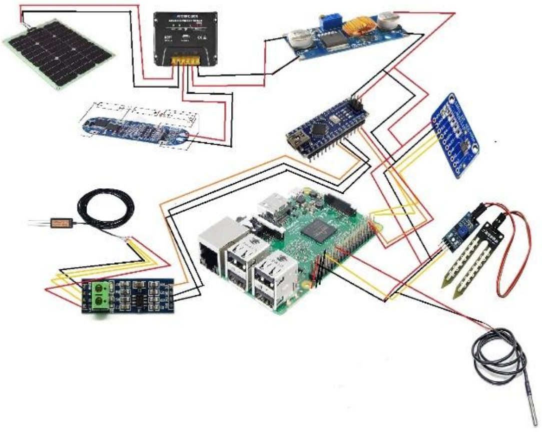
The Arduino Nano has a number of facilities for communicating with a computer, another Arduino, or other microcontrollers. The ATmega328 provides UART TTL (5V) serial communication, which is available on digital pins 0 (RX) and 1 (TX). An FTDI FT232RL on the board channels this serial communication over USB and the FTDI drivers (included with the Arduino firmware) provide a virtual com port to software on the computer. The Arduino software includes a serial monitor which allows simple textual data to be sent to and from the Arduino board.

Solar Panel:

Solar energy is a very important source of renewable energy that is available in abundance as compared to any other resource. The large magnitude of solar energy available makes it highly appealing for different applications across diverse verticals such as residential homes, industrial, manufacturing, agriculture, technology, etc.

The use of solar energy can be a revolutionary advancement for the agricultural sector, by adding value in many ways like saving precious water resources, reducing dependency on the grid, saving power costs in the long run and even becoming an additional revenue stream

CIRCUIT DIAGRAM



5. RESULTS

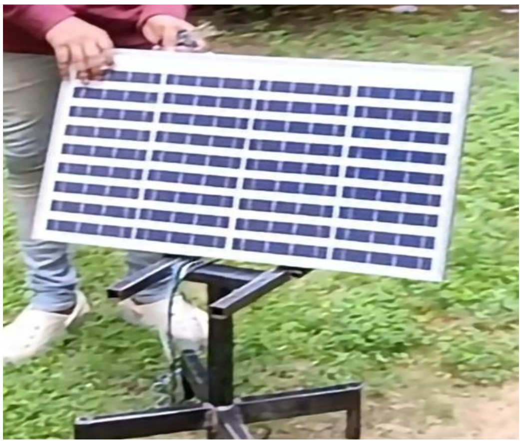


Fig.8

Fig.9

6. CONCLUSION

Advanced technologies like Deep Learning and IoT can transform the agriculture sector by providing real-time information on crop growth, disease control, and environmental conditions. Deep Learning algorithms can address the uncertainty in crop yields by accurately identifying plant diseases, leading to increased crop yields. Sensors can detect environmental factors for real-time monitoring, helping farmers optimize crop growth and yield while reducing water usage.

Data analytics can aid crop selection and management, leading to improved profitability and sustainability. Governments and private organizations should invest in research and development to ensure farmers can access these technologies, which have the potential to increase efficiency, reduce costs, and improve the livelihoods of farmers.

Prefixes such as “non,” “sub,” “micro,” “multi,” and “"ultra” are not independent words; they should be joined to the words they modify, usually without a hyphen. There is no period after the “et” in the Latin abbreviation *“et al.”* (it is also italicized). The abbreviation “i.e.,” means “that is,” and the abbreviation “e.g.,” means “for example” (these abbreviations are not italicized).

An excellent style manual and source of information for science writers is [9]

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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