International Research Journal of Innovations in Engineering and Technology (IRJIET)

ISSN (online): 2581-3048

Volume 8, Issue 5, pp 220-226, May-2024

https://doi.org/10.47001/IRJIET/2024.805032

Use of Machine Learning and Deep Learning along with NPK Sensor for Intelligent Farming Solutions

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***Abstract* - 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. It consists of an NPK sensor with a combination of machine learning models to monitor soil health and increase yields, reduce costs and match fertilizer supply with demand. It also helps to analyze various insects and provides descriptions of insects and recommends solutions to those insects in Nepali language helping farmers. The integration of ML and DL models such as random forest for fertilizer prediction, light GBM (Gradient Boosting Machine) for crop prediction and Conv2D for the classification of insects will help to maximize the production yield.**

Keywords: crop recommendation, fertilizer prediction, ML, NPK sensor, Light GBM, CNN.

I. INTRODUCTION

1.1 Background

One of the important industries that help to overcome food scarcity is agriculture. The success of reducing food scarcity depends upon the production. A primary cause of low yield is incorrect use of fertilizers and insecticides. Fertilizers can be added in the right amounts when the soil is deficient in nutrients by examining the nutrients in the soil required for plant growth which is done by soil testing. The primary result of soil testing is the recommendation of fertilizer for efficient plant growth. However, because of its complicated laboratory and manual process, farmers rarely perform it due to high costs and time requirements. Traditional methods often have limitations in terms of time-consuming and inadequate spatial resolution. NPK sensors provide a real-time, on-site analysis that help farmers to make decisions regarding fertilizers.

Machine learning, as a subset of artificial intelligence, provides different algorithms, tools and techniques required to analyze enormous amounts of data and information, and take predictive actions based on different technological trends. The Machine Learning algorithms make use of data gained from the NPK sensors, pH sensors, humidity sensors, different weather patterns, crop data and disease records for optimal output through the agricultural process.

In addition to mineral detection and fertilizer prediction, Machine Learning techniques have been extended to include the detection of crop diseases caused due to various living sources such as harmful insects using image processing. Image processing includes analyzing images of disease causing insects to identify visual symptoms associated with diseases or pest infestations. By integrating image processing with Machine Learning algorithms, farmers can be able to accurately and rapidly detect diseases, enabling timely interventions to prevent further crop damage and losses.

The integration of NPK sensors, ML algorithms, and deep learning has the potential to revolutionize agriculture through effective resource utilization, thereby reducing environmental impacts and pollution, and enhancing overall crop production. By leveraging the power of these technologies, farmers can transition to a data-driven approach that promotes efficiency and sustainability in agriculture. This report provides detailed aspects, including mineral detection, fertilizer prediction, crop production optimization, and pest detection.

1.2 Objectives

The primary objective of this research project is to create an AI enabled system to monitor crop production. This research project can help farmers monitor the soil nutrients and increase productivity.

1.3 Problem Statement

Conventional approaches to fertilizer application and insect disease diagnosis are imprecise, leading to inefficiencies and reduced crop productivity. Commercial laboratories manually evaluate the soil for nutrients, and that

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is time-consuming and expensive to support farming. There is a lack of advancements in technology that integrate NPK sensors and machine learning to enhance crop recommendations and fertilizer prediction more effectively, thereby improving overall crop management. This project aims to address these challenges by using NPK sensor data, pH and humidity data, processed with machine learning, and real-time image processing to give accurate fertilizer recommendations, estimate fertilizer needs, and detect disease causing pests at early stages. It aims to monitor every phase of the crop cycle from sowing and planting to harvesting.

II. LITERATURE SURVEY

Over the past few years, the agricultural sector has been revolutionized by the advancement of technology. One of the advancements is the integration of NPK (nitrogen, phosphorus, and Potassium) sensors and machine learning (ML) algorithms to optimize agricultural practices. This literature review aims to explore the existing research and developments related to mineral detection, fertilizer prediction, crop production, and weed and pest detection using image processing in the context of this integrated approach.

Research conducted by Palaniraj, Balamurugan, Durga Prasad, and Pradeep (2021) predicts the crop according to the soil nutrient content and the location where the crop is growing. This system will help farmers choose the right crop for their land and suggest a suitable amount of fertilizer for the maximum production of the crop. The Support Vector Machine algorithm helps to predict accurately with the help of the previously provided crop data. This system will also help to produce a good profit by recommending the right crop according to the soil nutrients for the newcomers in this field [1].

With the help of the research conducted by Sentil Kumar Swami Durai and Mary Divya Shamili (2022), farmers can now identify the crops they can grow according to their locality. As a result, insect pests affect crops, so it is important to detect and identify them as well as suggest Insecticides provide an effective approach for farmers in this regard. The reason behind this is that there are some variables that make it impossible for farmers to calculate the cost of cultivation which includes human labor, animal labor, seed, manures and fertilizers which we also call variable expenses. It also predicts fixed costs providing systematic instruction on planning activities and production technologies profitability [2].

Another study was conducted by M. Ayaz, M. Ammad-Uddin, Z. Sharif, and A. Mansour (2019) examines how IoT technologies have transformed agriculture, focusing on the use of quantitative methods and the incorporation of wireless sensors. It highlights the usage of UAVs for crop observation while talking about the advantages of loT in various agricultural applications. The article also lists present developments and problems in loT-based agriculture research. Overall, it offers meaningful information about the possible advantages and difficulties of IoT in the agriculture sector [3].

S. Sundaresan et al conducted research in 2023. A system has been created to suggest what crops are suitable based on the local weather and soil conditions. It further can automatically water plants when necessary and advise on the best fertilizers for various kinds of crops. This system is applicable for planting these types of crops such as; apples, rice, maize, grapes, cotton, and coffee beans among others. This system can serve as a decision-making support tool for farmers that will result in reduced manual labor, conserved energy and increased yields. The future prospects of this technology could involve addition of a disease prediction system using image recognition[4].

Research conducted by B. Cheruvu, S. B. Latha, M. Nikhil, H. Mahajan and K. Prashanth s.A farmer who has employed a smart farming system on his farm shall be capable of check-ing the soil nutrients in real time while using the recommendation system which is based on model trained with particular datasets to recommend best suited crop for the given soil. This system is more dependable and practical since it frequently gets important information about the environment directly from mineral nutrients content in soils, temperature variations, humidity levels as well as moisture status of soils through an interface that is simple to use. Lastly, farmers understand their plants' best condition ever[5].

The research was conducted by S.C.Karad. The article has the aim of explaining NPK Senost, where Indian farmers might see range changes in soil condition, climatic factors, rainfall, crop acreage and temperature. These sensors can be used to manage nutrient requirements and apply fertilizers when necessary leading to enhanced soil fertility hence maximum yield[6].

The research was conducted by Cojocaru, C., Ene, A., and Gojgar. This article aims at ob- serving soil quality for high yields and decreasing over-fertilization. It is an excellent tool for worldwide farmers to gather real-time data. Therefore, with the help of NPK sensors this also intends to improve soil health through monitoring of a problem area which will lead to increased production, bottom line costs reduction as well as filling the fertilizer accordingly for maximum yield[7].

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III. METHODOLOGY

3.1 Hardware Architecture for measuring soil parameters

The hardware components consist of an NPK, temperature and humidity sensor, moisture sensor, and a 16*2 LCD, which is controlled using an Arduino microcontroller. The data from all the sensors will be displayed on a screen controlled by a microcontroller. All the collected data is then applied to WebApp for further prediction. The interconnection of hardware components is represented by the block diagram given below.

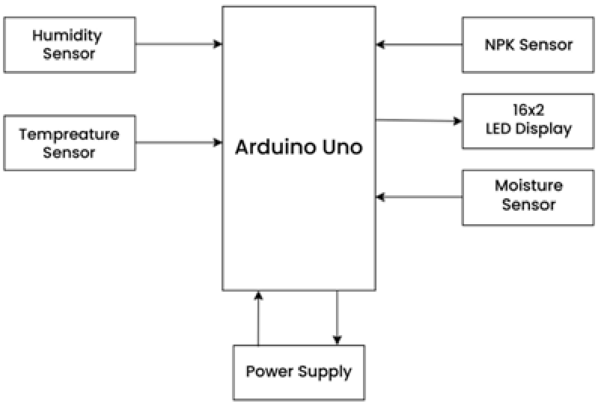

Figure 3.1: Hardware integration for measuring soil nutrients

3.2 Software Architecture

Software architecture mainly consists of client, UI, Application Server, Database, route gateway, and functions. The client/user login to the Webapp through User Interface. After logging in they can access the application server which then passes through the route gateway to perform a specific function as specified. The function component encompasses three models named as crop recommendation (light GBM used), fertilizer recommendation (random forest used), and pesticide suggestion (Conv2D).

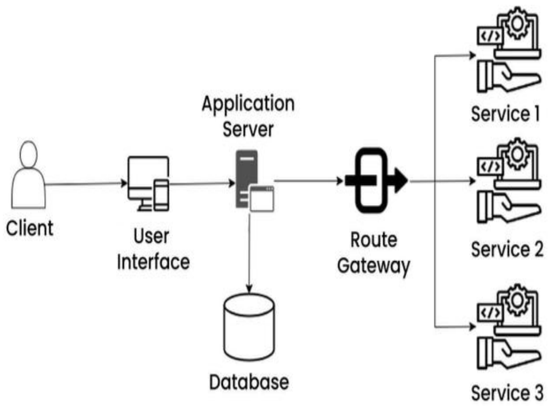

Figure 3.2: Software architecture for WebApp

3.3 Workflow

The user/client can open the app by logging in. They are directed to our web application landing page and can simply visit our website to use our services or learn about us. The services comprises of three sections listed below:

- Crop Recommendation:

The user gathers the required parameters through hardware and sensors. The sensor data is then filled to the Web App which identifies the crops to be cultivated. The prediction is done by the Light GBM model. The dataset for the model was collected from Kaggle. Light GBM is a gradient-boosting ensemble method that is based on decision trees. As with other decision tree-based methods, Light GBM can be used for both classification and regression. The predicted crop is then passed to the display page of the Web App, which provides information to the client.

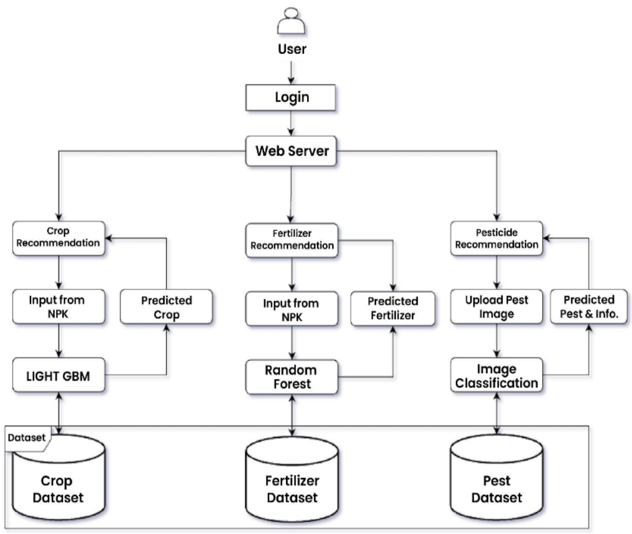

Figure 3.3: WorkFlow for Web app

- Fertilizer Prediction:

The user gathers the required parameters through hardware and sensors. The sensor data is then filled to the web app, which will identify the fertilizer required for specific crops. The dataset for the model was collected from Soil Research Centres, Pokhara and was trained with Random Forest Algorithm. It performs classification and regression tasks and provides decisions based on multiple decision trees. The algorithm introduces randomness by selecting subsets of features and data samples for each tree, enhancing overall robustness and generalization. The predicted fertilizer is then passed to the display page of the web app, which provides information to the farmers.

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- Pesticide Suggestion:

The user inserts the queried image into the web app. The image is then sent to the CNN (Conv2D classifier). The dataset was gathered through a web scraper, scaled, managed manually, and splitted for training and testing. A Conv2D classifier is a neural network layer specifically designed for image processing. It scans and then extracts features from input images using 2D convolutional filters, aiding in tasks like image recognition. The predicted image is then displayed on the result screen ni Nepali language with a description of insects and its resolving suggestion.

IV. MODEL ANALYSIS

4.1 Crop Recommendation

A crop recommendation system has been built by collecting various soil parameters and weather patterns. The data was preprocessed to remove inconsistencies and outliers, and relevant features were selected. Machine learning algorithm Light Gradient Boosting Model was chosen for its optimum accuracy and trained on the data. The data was then analyzed using Matplotlib to compare NPK values of different crops.

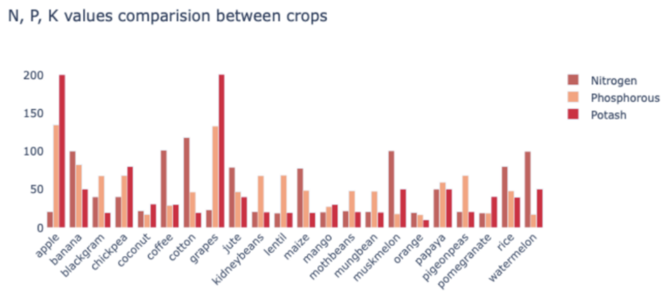

Figure 4.1: Analysis of NPK for different crop

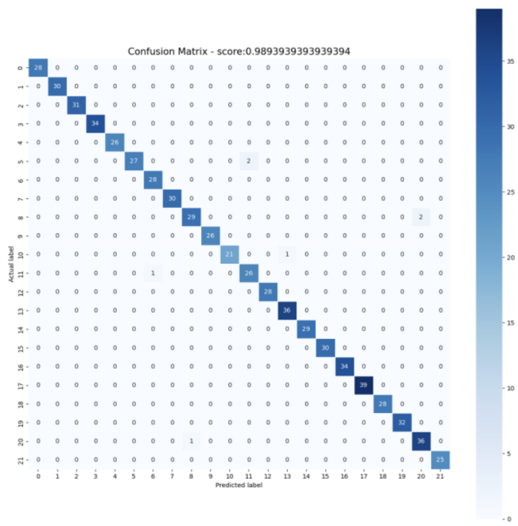

Figure 4.2: Correlation matrix

4.2 Fertilizer Recommendation

A fertilizer recommendation system has been built by collecting data through the local soil and research center and also from the kaggle. The data was preprocessed to remove ni-consistencies and outliers, and relevant features were selected. Machine learning algorithm Random was chosen for its optimum accuracy and trained on the data. This system was built with few datasets as data was difficult to gather. The data was then analyzed using Matplotlib to prepare a graph about which type of soil uses what type of fertilizers.

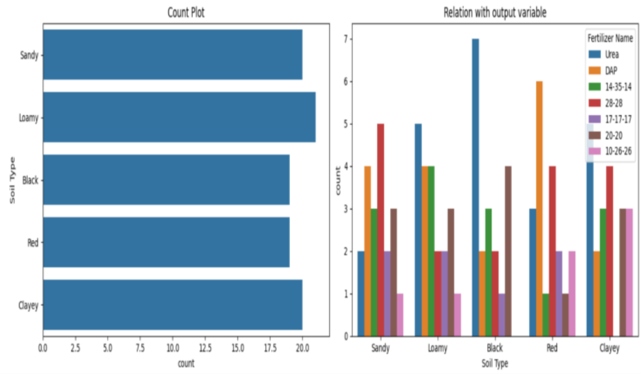

Figure 4.3: Analysis of soil type to suggest fertilizer

4.3 Insecticide Recommendation

The dataset was gathered through Web Scraper, scaled, man-aged manually, and splitted for training and testing. Conv2D classifier is a neural network layer specifically designed for image processing. It scans and extracts features from input images using 2D convolutional filters, aiding in tasks like image recognition. The plot of accuracy and loss is shown in 4.4 and 4.5.

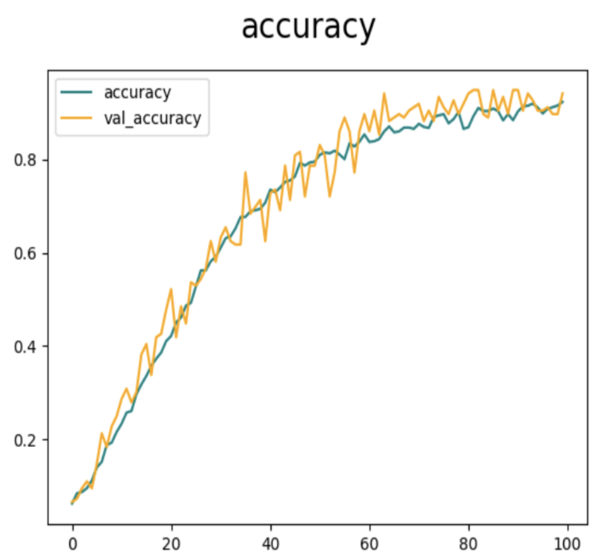

Figure 4.4: Training accuracy versus the Validation accuracy

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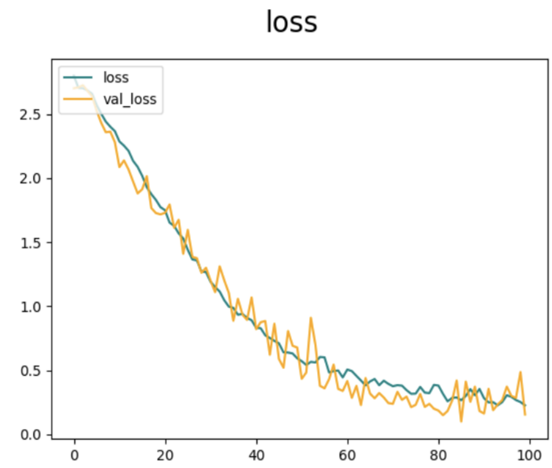

Figure 4.5: Training loss versus the validation loss

V. RESULTS AND DISCUSSION

5.1 Results

The implementation of NPK sensors along with other sensor parameters give data (10% tolerance) for measuring the various soil parameters (7 parameters used) for crop recommendation and fertilizer recommendation. The datasets were prepared using kaggle and through Soil and Research Centre, Gandaki .The Light GBM model used for the Crop Recommendation gave accuracy of 98 % and the use of Random Forest for fertilizer recommendation gave accuracy of 97 %. For Insecticide recommendation datasets of image were collected through Scrapper and manually cropped for the size and Conv2D model is used which gave accuracy of 92 %. The image of output of different web app features is given below:

5.2 Service

There are three services provided: Crop Recommendation, Fertilizer Prediction, and Pest-Insecticides Recommendation. The user can choose one according to their need. The new services and models can be added on later.

Figure 5.1: Services

5.3 Crop Recommendation

Farmers have to enter all the data collected from NPK sensors and click on the predict button for obtaining detail about the crop best suited for cultivation. With use of appropriate insecticide which is done in Nepali language. 15 common insects, worms, and flies data were trained.

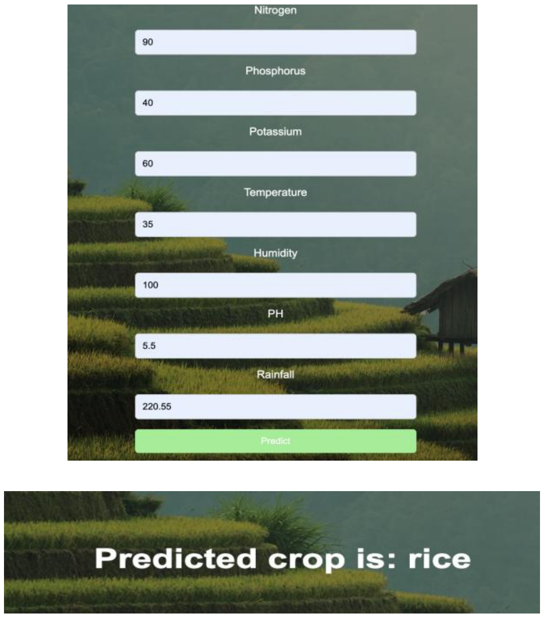

Figure 5.2: Crop Recommendation

5.4 Fertilizer Recommendation

Farmers have to enter all the data collected from NPK sensors and click on the predict button for obtaining details of fertilizer to be used for specific crops.

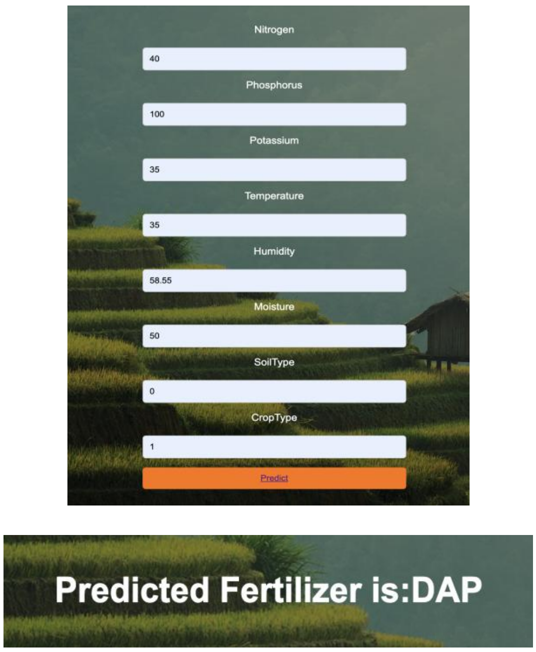

Figure 5.3: Fertilizer Recommendation

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5.5 Insect Description and Suggestion

This section explains and identifies the name and description of insects and provides suggestions to get rid of those insects.

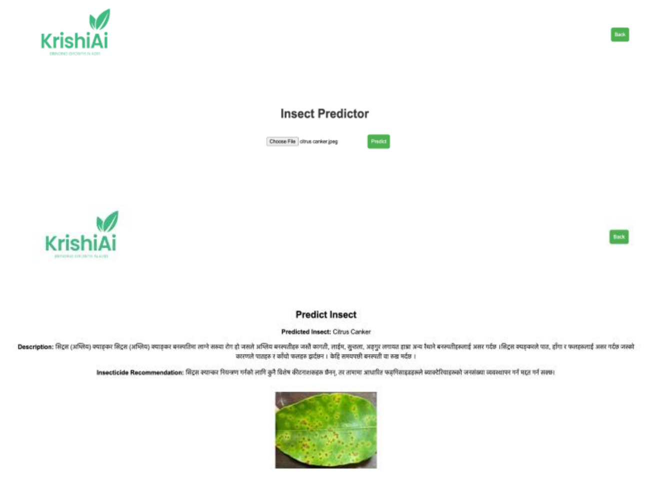

Figure 5.4: Fertilizer Recommendation

VI. CONCLUSION

The research gives understanding on the “Use of Machine Learning and Deep Learning along with NPK Sensor for Intelligent Farming Solutions” which focuses on being a major helping hand for farmers to increase their productivity. It plays an important role for solving food scarcity through the use of modern tools and technologies. Just like adding new features in software, the system can increase its features and services. The addition of the datasets will improve the accuracy of the system and make the system more reliable.

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I am a highly skilled Electronics, Communication and Information Engineer with a strong background in hardware and software development with prior knowledge in ML and AI along with networking skills.

I am an engineering student pursuing a bachelor degree in electronics and information engineering. I have a deep interest in the field of AI and machine learning.

I am a skilled Electronics and Information Engineer with a strong background in software development, particularly in backend development using programming language python along with networking skills.

I am an engineering student pursuing bachelor degree in electronics and communication and Information engineering from 2019 AD and expect to graduate in 2024 AD. Throughout the studies, I have developed passion in the field of AI and Machine Learning.

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https://doi.org/10.47001/IRJIET/2024.805032

Citation of this Article:

Shubham Thapa, Saphal Bhattarai, Basanta Subedi, Bibek Paudel, Hom Nath Tiwari, "Use of Machine Learning and Deep Learning along with NPK Sensor for Intelligent Farming Solutions", Published in *International Research Journal of Innovations in Engineering and Technology - IRJIET*, Volume 8, Issue 5, pp 220-226, May 2024. Article DOI https://doi.org/10.47001/IRJIET/2024.805032

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