AI Driven Interactive Agri Bot Providing Realtime Assistance in Cultivation and Market Linkages

M.Gomathi[1], G. A. Monika[2], M. Nachammai[3], A. Saranya[4], R. Shyni Deva Priya[5]

[1]Assistant Professor, Information Technology, Vivekanandha College of Technology for women, Namakkal, India.
[2,3,4,5]Student, Information Technology, Vivekanandha College of Technology for women, Namakkal, India.

Abstract
This project introduces an integrated system for smart agriculture, employing Internet of Things (IoT) technology for soil type analysis and deep learning methodologies for pest detection. The proposed system leverages a specialized NPK sensor for real-time measurement of soil nutrient levels, facilitating precision agriculture practices. Additionally, a Convolutional Neural Network (CNN) algorithm is employed to detect pests in crops, enhancing crop management efficiency and yield optimization. The IoT-based NPK sensor enables farmers to monitor essential soil nutrients such as nitrogen (N), phosphorus (P), and potassium (K) levels remotely and in real-time. This data empowers farmers to make informed decisions regarding fertilization strategies, ensuring optimal nutrient balance for healthy plant growth while minimizing resource wastage and environmental impact. To the deep learning framework, specifically CNN, is utilized for pest detection in crops. By analyzing images captured from smart agricultural cameras, the CNN model can identify and classify various pests and diseases affecting crops. This enables early detection and intervention, thereby mitigating potential crop damage and yield losses. The integration of CNN-based pest detection with IoT infrastructure enables timely and targeted pest management actions, reducing reliance on chemical pesticides and promoting sustainable agricultural practices.

Keywords: CNN, NPK sensor, IOT, Deep Learning.

1. Introduction

Soil testing is a fundamental practice in modern agriculture that plays a crucial role in ensuring optimal crop production, environmental sustainability, and economic viability for farmers. By assessing the physical, chemical, and biological properties of soil, farmers gain valuable insights into its fertility, nutrient content, and overall health. This information serves as the foundation for making informed decisions regarding fertilizer application, crop selection, and land management practices. The significance of soil testing in agriculture stems from its ability to provide precise and actionable data tailored to the specific needs of each field or crop. Through comprehensive soil analysis, farmers can determine nutrient deficiencies or imbalances, identify soil pH levels, assess soil texture and structure, and evaluate potential risks from contaminants or pathogens. Armed with this knowledge, farmers can develop targeted fertilization strategies, select appropriate crop varieties, and implement soil conservation measures to optimize yields and minimize environmental impact. Moreover, soil testing serves as a cornerstone of sustainable agriculture practices, promoting resource efficiency and environmental stewardship. By accurately assessing soil fertility and nutrient status, farmers can avoid over-application of fertilizers, reduce nutrient runoff into waterways, and mitigate soil degradation. This not only enhances agricultural productivity but also helps preserve natural ecosystems and protect water quality for future generations. In recent years, advancements in technology, particularly in the field of IoT and sensor technologies, have revolutionized soil testing practices, enabling real-time monitoring and data-driven decision-making. IoT-enabled soil sensors provide farmers with instantaneous feedback on soil parameters such as moisture levels, temperature, and nutrient concentrations, allowing for timely adjustments in irrigation and fertilization regimes. Additionally, integration with data analytics platforms allows for the interpretation of sensor data and generation of actionable insights for improved crop management.

1.1 Pest Disease

Plants play a vital role in sustaining life on Earth, serving as sources of oxygen, food, and habitat for countless organisms. However, they face numerous challenges, including attacks from pests and diseases that can significantly impact their health and productivity. Among these threats, plant leaf pests and diseases stand out as particularly troublesome, capable of causing widespread damage to crops, ornamental plants, and natural ecosystems. Plant leaves, with their intricate structures and vital roles in photosynthesis and transpiration, are prime targets for pests and pathogens. Leaf pests encompass a wide range of insects, mites, and other organisms that feed on leaf tissues, causing damage through chewing, sucking, or mining. Meanwhile, leaf diseases, caused by fungi, bacteria, viruses, and other pathogens, can manifest as spots, blights, rusts, wilts, and other symptoms that compromise leaf function and plant vitality. Effective management of plant leaf pests and diseases is essential for safeguarding plant health, ensuring food security, and maintaining ecosystem integrity. Integrated pest management (IPM) approaches that combine cultural, biological, physical, and chemical control methods are often employed to mitigate pest and disease pressures while minimizing environmental impacts and promoting sustainable practices.Understanding the biology, ecology, and behavior of leaf pests and diseases is crucial for developing targeted management strategies. Furthermore, early detection, accurate diagnosis, and timely intervention are key components of successful pest and disease management programs. Collaboration among researchers, growers, extension agents, and policymakers is essential for advancing knowledge, developing innovative solutions, and implementing effective measures to address the challenges posed by plant leaf pests and diseases.

1.2 Internet of Things

In today's interconnected world, where devices ranging from smartphones to home appliances are becoming smarter and more connected, the Internet of Things (IoT) stands at the forefront of technological innovation. At its core, IoT refers to the network of physical objects or "things" embedded with sensors, software, and other technologies, enabling them to collect and exchange data with other devices and systems over the internet. The concept of IoT has transformed the way we interact with our surroundings, blurring the lines between the physical and digital realms. From smart homes equipped with thermostats, lights, and security cameras that can be controlled remotely, to industrial machinery that can self-monitor and optimize performance, IoT has ushered in an era of unprecedented convenience, efficiency, and connectivity. Key to the success of IoT is the seamless integration of hardware, software, and connectivity solutions. Sensors embedded within IoT devices gather data from the environment, which is then transmitted to a central system or cloud platform for analysis and action. This data-driven approach enables real-time monitoring, predictive maintenance, and automation across various industries and applications. Moreover, the proliferation of IoT devices has led to the generation of vast amounts of data, often referred to as "big data." Leveraging advanced analytics and machine learning algorithms, organizations can derive valuable insights from this data, driving informed decision-making and unlocking new opportunities for innovation and growth. However, along with its promise comes challenges such as data privacy and security concerns, interoperability issues, and the need for robust infrastructure and standards. As IoT continues to evolve, addressing these challenges will be crucial in realizing its full potential while ensuring a secure and sustainable future.

2. Literature Survey

Analysis of Soil Type by Image Using Neural Networks, Author: Nikita O. Tursukov; Mikhail S. Kupriyanov, Year:2024, The study of soil and terrain is an important aspect in agriculture. It allows to classify terrain based on soil images, including aerial photography. The method classifies each pixel of the image using window traversal as a result, the accuracy of recognition can be increased by carefully examining each portion of the image and taking into account the classes that have been assigned to it.

Conventional to Modern Methods of Soil NPK: A Review, Author: Sneha Dattatreya; Abdul Naim Khan, Year: 2023, Sensing technology has long been used to measure soil nutrient levels precisely without the need for costly, time-consuming, and traditional laboratory tests.

Agronomic Soil Testing Miniature with WSN, Author: M. Pallikonda Rajasekaran; K. Rajesh; R. Jenitha, Year: 2023, Agriculture is considered to be the main resource for the growth of a country. As the population grows drastically, agriculture is a field that needs to be concentrated to feed the entire community. To meet the entire demand, farmers are handling many short-cut techniques to harvest crops within a shorter period. Crop health is not well understood by experimenting with many fast-growing techniques; ultimately, the consumer who is consuming the crop is also affected. To mitigate these issues, which carefully looks at the healthy yield that fits into the proper time frame, precision agricultural technology comes into play. The module helps the farmer to analyze the particular field that is sufficient to grow healthy crops. The developed model is tested for its functionality in a farm and analyzed. The crop health is being compared with the crop being tested with the developed model and without the model. From the real-time test analysis, the developed model produced effective growth with proper monitoring.Soil Classification using Deep Learning Techniques, Author:D.Sivabalaselvamani; L. Rahunathan; K. Nanthini, Year: 2023, The study of soil categorization is a burgeoning field nowadays. This study is to classify the different types of soils like Clay soil, Black soil, Red soil and Alluvial soil by using CNN algorithm. Classifying soil is important in fields like farming, geology, and engineering. Along with that other deep learning methods can also be employed to enhance accuracy. The image datasets used in this study were obtained from Kaggle and underwent processing with various algorithms. Afterwards, performance metrics were employed to compare the results. To efficiently classify the images based on their labels, VGG19 is used, which is a subset of CNN. This study enables us to effectively classify soil images. The models are trained on a dataset of soil images that had been labeled with their corresponding soil type. This model achieves an accuracy of 94.87% on the test set.

Detection of Plant Disease and Pests using Coherent Deep Learning Algorithms, Author : Pratibha Nayar; Shivank Chhibber, Year : 2023, This paper shows a comparative study of various YOLO versions on the PlantDoc and Our own curated Plant Disease and Pest Detection Models based on YOLO versions v7 and v8 and the capacity to carry out detection considerably more quickly and precisely than the current models created earlier.

3. Proposed Work

Precision Farm AI is a groundbreaking mobile application poised to transform agricultural practices by harnessing the power of Artificial Intelligence (AI) and data analytics. With a core focus on empowering farmers, the system aims to provide personalized and real-time guidance to enhance decision-making in farming activities. Leveraging cutting-edge technologies, Precision Farm AI offers a comprehensive suite of features and functionalities tailored to address the evolving needs and challenges faced by modern farmers.

The proposed methods of the project entail the integration of Internet of Things (IoT) technology and deep learning methodologies to create a comprehensive system for smart agriculture. The project utilizes IoT devices, specifically a specialized NPK sensor, for real-time measurement of soil nutrient levels. This sensor enables farmers to remotely monitor crucial soil nutrients such as nitrogen (N), phosphorus (P), and potassium (K), empowering them to make informed decisions regarding fertilization strategies. By ensuring optimal nutrient balance, farmers can promote healthy plant growth while minimizing resource wastage and environmental impact. In addition to soil analysis, the project incorporates deep learning techniques, specifically a Convolutional Neural Network (CNN) algorithm, for pest detection in crops. Utilizing images captured from smart agricultural cameras, the CNN model can analyze and classify various pests and diseases affecting crops. This enables early detection and intervention, helping to mitigate potential crop damage and yield losses. By integrating CNN-based pest detection with the IoT infrastructure, the system facilitates timely and targeted pest management actions. This reduces reliance on chemical pesticides, promoting sustainable agricultural practices while enhancing crop management efficiency and yield optimization.

Beyond its immediate benefits to individual farmers, Precision Farm AI has the potential to drive broader systemic improvements in the agricultural sector. By promoting sustainable farming practices, optimizing resource utilization, and minimizing environmental impact, the application contributes to the long-term viability and resilience of agricultural systems. Moreover, by facilitating data-driven decision-making and precision agriculture techniques, Precision Farm AI helps enhance food security, mitigate climate change impacts, and promote economic development in rural communities.

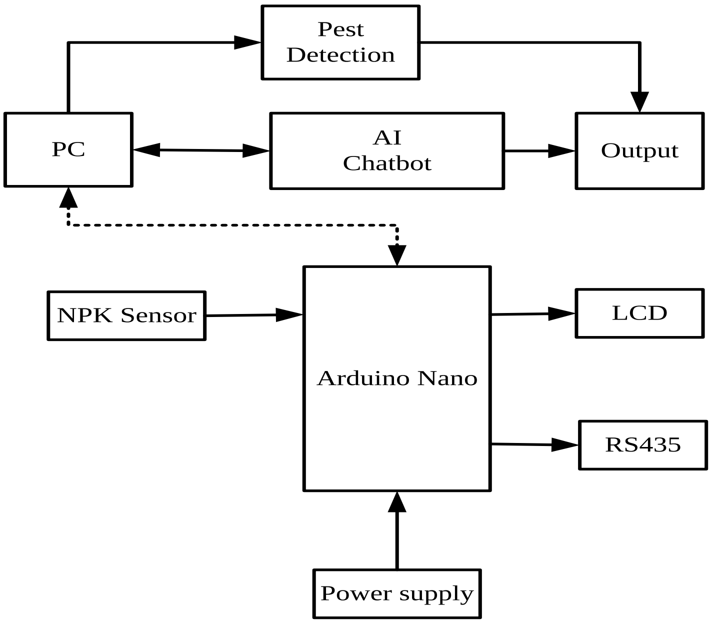

Figure 1. Proposed System

3.1 Project Description

1. Data Acquisition and Integration Module
   - Admin
   - Chatbot Module
2. Predictive Modeling and Analysis Module
3. User Interface and Decision Support System
4. Optimization and Recommendation
5. IoT Sensor Module (NPK)

3.2 Module Description

The Data Acquisition and Integration Module is the foundational component of the system, tasked with collecting data from diverse sources crucial for agricultural decision-making. It orchestrates the retrieval of data from IoT sensors, weather databases, and historical agricultural records. The Admin component plays a pivotal role in managing user access rights, overseeing data storage infrastructure, and safeguarding data integrity through rigorous protocols. Additionally,sthe Chatbot Module engages with users to augment the data collection process, soliciting supplementary information and offering real-time assistance. By seamlessly integrating these functionalities, the module ensures a continuous influx of relevant data and facilitates interactive communication, laying the groundwork for informed agricultural decisions and personalized user experiences. Predictive Modeling and Analysis module utilizes sophisticated algorithms to analyze diverse datasets, including soil composition, weather patterns, historical agricultural data, and pest incidence records. Through machine learning and statistical methods, it identifies patterns and correlations within the data to predict various agricultural outcomes. For instance, it can forecast soil health indicators, such as nutrient levels and pH balance, as well as predict crop growth trajectories based on environmental factors. User Interface and Decision Support System module serves as a user-friendly gateway for farmers to interact with the agricultural system. It presents data analysis results through intuitive visualizations, making complex information easily understandable. Personalized recommendations based on the farmer's specific needs and conditions are provided, guiding them towards optimal farming practices. Farmers receive alerts about potential issues such as soil nutrient deficiencies or pest outbreaks, enabling proactive management. Decision support tools help farmers make informed choices about irrigation, fertilization, and crop rotation, ultimately improving productivity and sustainability. Optimization and Recommendation module leverages predictive models and data analysis to offer customized suggestions aimed at enhancing agricultural productivity. By analyzing various factors such as soil health, weather patterns, and historical data, the system generates optimized strategies. These strategies may include adjusting fertilizer application rates to meet specific nutrient needs, optimizing irrigation schedules to conserve water and prevent overwatering, and recommending crop rotation plans to maintain soil fertility and minimize pest infestations. IoT Sensor Module (NPK) module employs IoT sensors to continuously monitor soil nutrient levels, specifically Nitrogen, Phosphorus, and Potassium (NPK). These sensors are embedded in the soil and collect data on nutrient concentrations. By providing real-time information on nutrient levels, farmers can precisely manage fertilization schedules and adjust nutrient application rates as needed. This ensures that crops receive the appropriate balance of nutrients for healthy growth and maximum yield, ultimately optimizing agricultural productivity.

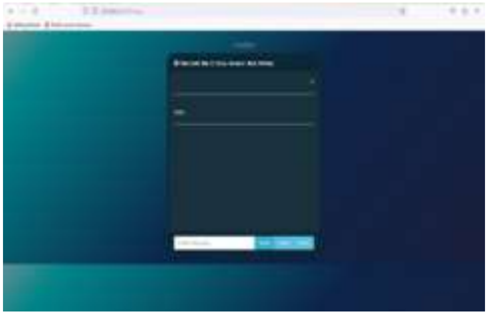

Figure 2. Chatbot

3.3 Hardware Description

The term is most commonly applied to electrical energy supplies, less often to mechanical ones, and rarely to others.

Transformer

A changing current in the first circuit (the primary) creates a changing magnetic field; in turn, this magnetic field induces a changing voltage in the second circuit (the secondary). By adding a load to the secondary circuit, one can make current flow in the transformer, thus transferring energy from one circuit to the other. The ratio of the number of turns of wire in each winding's secondary induced voltage (VS) to the main induced voltage (VP) is ideally equal to:

$$\frac{V_S}{V_P} = \frac{N_S}{N_P}$$

Transformers are some of the most efficient electrical 'machines', with some large units able to transfer 99.75% of their input power to their output. Transformers come in a range of sizes from a thumbnail-sized coupling transformer hidden inside a stage microphone to huge gigavolt-ampere-rated units used to interconnect portions of national power grids. All operate with the same basic principles, though a variety of designs exist to perform specialized roles throughout home and industry.

IC Part	Output Voltage (V)	Vi (V)
7805	+5	7.3
7806	+6	8.3
7808	+8	10.5
7810	+10	12.5
7812	+12	13.6
7815	+15	17.7
7818	+18	21.0
7824	+24	27.1

Table 1. Positive Voltage Regulators in 7800 series

Arduino Nano Pinout Description

Taking this pin-out diagram below as reference, we shall discuss all the functionalities of each and every pin

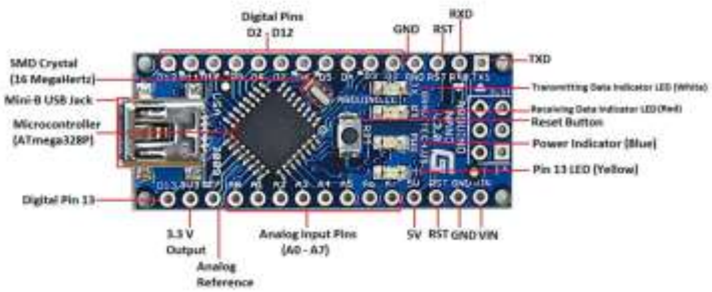

Figure 3. Arduino Nano Pinout

Figure 4. LCD Display

Pin No	Function	Name
1	Ground (0V)	Ground
2	Supply voltage; 5V (4.7V – 5.3V)	Vcc
3	Contrast adjustment; through a variable resistor	VEE
4	Selects command register when low; and data register when high	Register Select
5	Low to write to the register; High to read from the register	Read/write
6	Sends data to data pins when a high to low pulse is given	Enable
7	8-bit data pins	DB0
8		DB1

9		DB2
10		DB3
11		DB4
12		DB5
13		DB6
14		DB7
15	Backlight VCC (5V)	Led+
16	Backlight Ground (0V)	Led-

Table 2. Pin Description

4. Conclusion

The integrated system for smart agriculture presented in this project represents a significant advancement in leveraging technology to address key challenges faced by farmers. By combining Internet of Things (IoT) technology for soil type analysis with deep learning methodologies for pest detection, the proposed system offers a comprehensive solution for precision agriculture practices. The specialized NPK sensor provides real-time measurement of soil nutrient levels, empowering farmers to make informed decisions about fertilization strategies and ensuring optimal nutrient balance for healthy plant growth. This not only enhances crop productivity but also minimizes resource wastage and environmental impact. Additionally, the utilization of a Convolutional Neural Network (CNN) algorithm for pest detection enables early identification and classification of pests and diseases affecting crops. By analyzing images captured from smart agricultural cameras, the CNN model facilitates timely intervention, reducing crop damage and yield losses. Moreover, the integration of CNN-based pest detection with IoT infrastructure enables targeted pest management actions, promoting sustainable agricultural practices and reducing reliance on chemical pesticides. Overall, the integrated system offers a holistic approach to crop management, enhancing efficiency, productivity, and sustainability in modern agriculture.

5. References

1. M. Akram, S. Naz and T. Abbas, "Complex q-rung orthopair fuzzy 2-tuple linguistic group decision-making framework with Muirhead mean operators", Artif. Intell. Rev., vol. 56, no. 9, pp. 10227-10274, Sep. 2023.
2. SAMEER QAZI, BILAL A. KHAWAJA and QAZI UMAR FAROO, " AI-Enabled Next-Generation Smart Agriculture: A Critical Analysis of Present Issues and Upcoming Developments", vol. 10, 2022.
3. Manish Kumar, Ahlad Kumar and Vinay S. Palaparth, " Soil Sensors-Based Machine Learning and Exploratory Data Analysis Prediction System for Plant Diseases", IEEE Sensors Journal, vol. 21, no. 16, August 2021.
4. Chowdhury R. Rahman, Preetom S. Arko, Mohammed E. Ali, Mohammad A. Iqbal Khan, Sajid H. Apon, Farzana Nowrin, et al., " Using convolutional neural networks, rice illnesses and pests may be identified and recognized", March 2020.
5. Yan Guo, Jin Zhang, Chengxin Yin, Xiaonan Hu, Yu Zou, Zhipeng Xue, et al., "Plant Disease Identification Based on Deep Learning Algorithm in Smart Farming", Hindawi, August 2020.

6. D. J. A. Rustia, C. E. Lin, J. Y. Chung and T. T. Lin, " A Real-Time Insect Pest Identification Method Using Cascaded Convolutional Neural Networks for Various Classes", Proc. of 9th Int. Symp. on Machinery and Mechatronics for Agric. and Biosystems Eng, 2018.
7. Y. Shen, H. Zhou, J. Li, F. Jian and D. S. Jayas, "Detection of Stored-grain Insects using Deep Learning", Computers and Electronics in Agric, vol. 145, pp. 319-325, 2018.
8. N. Bhatt and D. Patel, "Insect Identification Among Deep Learnings Meta-architectures Using TensorFlow", Int. Journal of Eng. and Advanced Tech, vol. 9, no. 1, pp. 1910-1914, 2019.
9. C. Xie, R. Wang, J. Zhang, P. Chen, W. Dong, R. Li, et al., "Multi-level Learning Features for Automatic Classification of Field Crop Pests", Comput. And Electron. in Agric, vol. 152, pp. 233-241, 2018.
10. L. Deng, Y. Wang, Z. Han and R. Yu, "Research on Insect Pest Image Detection and Recognition based on Bio-inspired Methods", Bio-systems Eng, vol. 169, pp. 139-148, 2018.