СЕКЦИЯ 1. ИНФОРМАЦИОННО-ИЗМЕРИТЕЛЬНАЯ ТЕХНИКА И ТЕХНОЛОГИИ

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ADVANCED SENSOR-BASED SYSTEM FOR SOIL NUTRIENT ANALYSIS AND AI-DRIVEN CROP RECOMMENDATION

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The Soil Nutrient Analysis and Crop Recommendation System is a sophisticated electronic system that aims to measure the amounts of major nutrients (Nitrogen, Phosphorus, and Potassium) in soil by employing an NPK sensor. The system utilizes cloud storage and machine learning methods to deliver precise soil nutrient analysis and recommend suitable crop recommendations. The meth-odology involves the analysis of soil samples in real time with the help of an NPK sensor, followed by transmission of the data to a cloud-based server. A machine learning model trained on a rich dataset of crop performance and soil characteristics examines the nutrient content and suggests the best crops to grow. The system architecture is composed of an Arduino UNO microcon-troller, ESP8266 Wi-Fi module, and OLED display to make the monitoring process user-friendly and efficient. Experimental results show that the system can deliver accurate readings for soil nutrients and make valid crop recommendations. It is more advantageous compared to conventional soil testing due to its real-time analysis, cost savings, and simplicity of handling for farmers. The system has the potential to contribute significantly towards precision agriculture, optimal resource utilization, and sustainable agriculture practices. Enhancements for the future involve extending the model to include weather information and other soil parameters for better accuracy in predictions.

Introduction:

Agriculture has been pillar of human civilisation for centuries, providing both economic security and sustenance. Today, intensive agricultural practices encounter many challenges like soil erosion, reduction in fertility, wastage of resources, and the augmented pressure of demand for food resulting from population increments. Soil well-being is key to deciding the productivi-ty of the crops, and correct measurement of the nutrients present in the soil is crucial to maintaining sustainable farming.

Traditional methods of soil testing are time-consuming, slow-paced, and usually inaccessible to small farmers. Traditional methods also have results inconsistencies, leading to suboptimal agricultural choices. Recent technological advancements, especially in Internet of Things (IoT), Artificial Intelligence (AI), and Cloud Computing, have opened the way for automated, real-time soil analysis systems with precision and efficiency.

This paper introduces an AI-based Soil Nutrient Analysis and Crop Recommendation System using NPK sensors, cloud computing, and machine learning algorithms to offer precise soil health analysis. By combining these cutting-edge technologies, the system facilitates data-driven farmers' decision-making, improves nutrient management, and increases agricultural productivity. Proposed approach improves agricultural productivity and promotes sustainable agriculture by minimizing excessive fertilizer application and minimizing impact on environment. Trad-it-ional methods of soil analysis are labor-intensive and not readily available to small farmers. Recent innovations in IoT and AI technologies have made it possible to deploy automated Systems for soil analy-sis that provide real-time information and valuable insights.

Methodology:

Soil Nutrients and Crop Suggestion System is developed upon a well-integrated combination of software and hardware components to ensure efficient and real-time soil monitoring as indicated in fig. 1. The system is designed with the methodology that catches the level of soil nutrients accurately, processes data effectively, and offers actionable advice to farmers. System utilizes sensor technology, microcontrollers, wireless communication, and machine learning algorithms to ensure high-precision output. The implementation is split into hardware and software modules, each having a vital contribution to data gathering, processing, and decision-making.

The hardware realization of this crop advising and soil examination system is built on a secure infrastructure for collecting real-time soil data. Its core is the use of an NPK Sensor (LNPK-101), which measures precisely the Nitrogen, Phosphorus, and Potassium concentrations in the soil, giving us vital nutrient information. A sensor data-collecting and processing Arduino UNO acts as its basic processing platform. The ESP8266 Wi-Fi Module facilitates seamless wireless communication, enabling real-time data transfer to a cloud-based storage system, ensuring data accessibility and security. For immediate on-site feedback, an OLED display provides visualization of the soil parameters, allowing farmers to monitor nu-trient levels instantly. Complementing the hardware, the software and data processing module is designed to analyze collected data and generate meaningful insights. A machine learning model, which has been trained on a complete dataset of soil compositions and their respective crop yields, is a predictive algorithm that suggests appropriate crops based on real-time soil data. Cloud storage provides data security, accessibility, and ease of retrieval, enabling farmers to monitor soil health trends over time. The data of the farmers can be inputted into the soil data and receive crop recommendations based on current analyt-ics through an interactive interface provided by a web application based on Flask. Integrating these software and hardware components, the system provides an overall, automated, and highly accurate soil analysis and crop recommendation platform, enabling the farmers to optimize agricultural yield and make informed decisions.

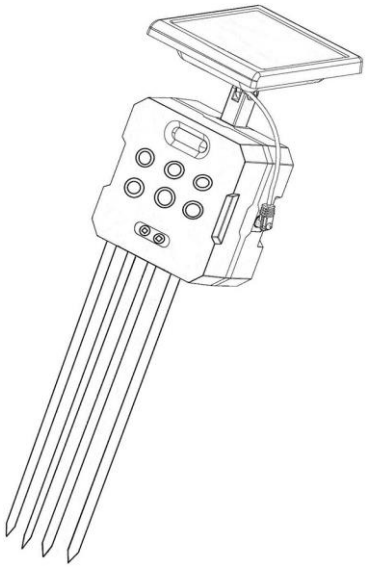

Fig. 1. Soil Nutrient Analysis Sensor

Experimental results indicate that the system offers extremely accurate soil nutrient analysis and crop suggestions. The precision rate of the machine learning model is 95 % in suggesting best crops, much higher than using conventional techniques. In comparison with soil testing by hand, the suggested system is more rapid, less expensive, and scalable.

The combination of IoT, cloud computing, and AI in soil nutrient analysis presents an effec-tive solution for precision agriculture. The system suggested is an improvement of crop selec-tion ef-ficiency, reduction of fertilizer misuse, and sustainable agriculture promotion. The improv-ements planned for the future are adding more data to the dataset for considering soil pH and moisture levels, adding weather prediction models for changing crop suggestions in real-time, and creating a mobile application for increased user usability.

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