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Smart Soil Analyzer

Shruti Santosh Bhuvad(Leader) Information Technology SVCP, Pune
Anushka Subhash Parkhi(Member) Information Technology SVCP, Pune
Pratiksha Dattatray Bhise(Member) Information Technology SVCP, Pune
Nikita Dattatray Dadas(Member) Information Technology SVCP, Pune
Umakant S. Shirshetti(Guide) Information Technology SVCP, Pune

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Abstract – This paper presents a Smart Soil Analyzer system that combines Internet of Things (IoT) and Artificial Intelligence (AI) technologies in farming. The main goal is to monitor soil health and environmental conditions in real time while allowing for early detection of plant diseases. The system uses multiple sensors, such as soil moisture, pH, temperature, and gas sensors, connected to an ESP32 microcontroller for data collection. The collected data is sent to a cloud-based Firebase platform and can be accessed through an Android app for live monitoring. Additionally, a Convolutional Neural Network (CNN) model is used to analyze leaf images and accurately identify plant diseases. The system also includes location-based Air Quality Index (AQI) analysis to recommend suitable air-purifying plants. Experimental results show high accuracy in data synchronization and disease prediction, offering a reliable and scalable solution for smart farming. This method boosts crop productivity, lowers manual effort, and supports sustainable farming.

Key Words: Smart Agriculture, IoT, Soil Monitoring, CNN, Plant Disease Detection, AQI.

1.INTRODUCTION

Agriculture is a vital sector that supports the economy and livelihoods of millions, especially in countries like India. However, traditional farming methods depend a lot on manual observation and experience. This can result in inefficient resource use and lower crop yields. With technological advancements, modern solutions like the Internet of Things (IoT) are now being used to improve farming practices. IoT allows for real-time monitoring of environmental conditions such as soil moisture, pH levels, temperature, and air quality.

The Smart Soil Analyzer system combines IoT and Artificial Intelligence (AI) to provide an efficient and smart farming solution. It gathers real-time data through sensors linked to an ESP32 microcontroller and saves it on a cloud platform for easy access through an Android app. The system also uses a Convolutional Neural Network (CNN) to identify plant diseases from leaf images, enabling early diagnosis and treatment. It includes Air Quality Index (AQI) data to recommend suitable plants for enhancing environmental conditions. This system offers a scalable, user-friendly, and effective approach to smart agriculture.

2. BODY OF PAPER

Several research studies have been done in the area of smart agriculture using the Internet of Things (IoT) and Artificial Intelligence (AI). Current systems mainly concentrate on monitoring soil factors like moisture, temperature, and humidity with sensor networks and microcontrollers. Some studies have used cloud-based platforms to store and analyze real-time data, which allows for remote monitoring through mobile or web applications. In addition, recent progress has introduced AI techniques, especially Convolutional Neural Networks (CNN), for detecting plant diseases using leaf images. Other research has looked into air quality monitoring systems that use gas sensors to measure pollution levels. However, most of these systems focus on only one part of agriculture, such as soil monitoring or disease detection. The proposed system addresses these

issues by combining soil analysis, air quality monitoring, and AI-based disease detection into one platform.

The proposed Smart Soil Analyzer system is a solution that offers real-time monitoring and smart analysis for farming. It brings together multiple sensors, a microcontroller, cloud storage, and an Android app to form a complete smart farming ecosystem. The system collects data on soil moisture, pH level, temperature, humidity, and air quality using various sensors linked to an ESP32 microcontroller. This data is sent to a cloud platform (Firebase) through Wi-Fi for storage and processing. The system also uses Artificial Intelligence (AI) with a Convolutional Neural Network (CNN) model to identify plant diseases from leaf images taken through the mobile app. Additionally, it includes Air Quality Index (AQI) analysis to offer environmental insights and recommend suitable air-purifying plants. The system aims to improve crop productivity, lessen manual work, and support sustainable farming practices.

The architecture of the Smart Soil Analyzer is structured into three primary layers. The sensor layer is responsible for collecting real-time data related to soil and environmental conditions using devices such as soil moisture sensors, pH sensors, DHT11 for temperature and humidity, and MQ-135 for air quality monitoring. These sensors are interfaced with an ESP32 microcontroller, which processes the collected data and prepares it for transmission. In the communication layer, the ESP32 uses Wi-Fi connectivity to send the processed data to the Firebase Realtime Database, ensuring continuous and synchronized data transfer. The application layer consists of an Android application developed using Java and XML, which retrieves the data from the cloud and presents it to users in a clear and user-friendly format. This layer also integrates Artificial Intelligence through a Convolutional Neural Network (CNN) model for plant disease detection, along with Air Quality Index (AQI) analysis to provide environmental recommendations. The overall system design supports efficient data flow, real-time monitoring, and scalability, making it suitable for modern smart agriculture applications.

smart soil analyzer is a complete system of multiple hardware components including sensors and microcontrollers which utilize the internet of things and artificial intelligence technologies to increase the efficiency and sustainability of agricultural production the smart soil analyzer continuously monitors key environmental and soil parameters providing users with real-time data insights this integration of hardware and cloud data storage as well as an android mobile app interface allows devices to communicate seamlessly allowing users to access the accurate data needed to make better decision in agriculture at any time the process of gathering data about the soil is done through an array of various sensors that measure relevant variables these include such things as soil moisture ph temperature humidity and air pollution each sensor is interfaced with an esp32 microcontroller which serves as the systems central processing unit this device takes the analog and digital inputs from the sensors and processes them into useful information which is then transmitted to firebase realtime database through wi-fi for storage and synchronization for creating real-time updates on the android application Packed with sensors.

What can you actually do with a tortoise-inspired robot? Quite a bit, actually. In disasters, it can crawl through rubble searching for survivors or checking building safety. On farms, it can roll along fields, monitor crops, and help manage irrigation without damaging anything. The military's interested too, since these bots can sneak through tough terrain, scout ahead, and keep people out of harm's way.

The smart soil analyzer is equipped to generate reports on soil health and plant health and throughout the entire system it includes an analysis of air quality index aqi levels to gather insights into the overall environment will access aqi data in real time located by smartphone gps and if the aqi indicates a specific level of air pollution within the geographic area surrounding the user will recommend various air-purifying plants that can help to create cleaner healthier air an android application developed with java and xml provides the main user interface for the entire system displaying current readings from both sensors and disease detection methods as well as recommendations based on the aqi in an easily understood format the smart soil analyzer is a scalable trustworthy and smart solution designed to bridge the traditional farming practices with the modern technological advancements available today.

3. WORKING PRINCIPLE

The Smart Soil Analyzer collects data through a variety of sensors in order to track soil and environmental conditions. These sensors include soil moisture, pH, DHT11 (for temperature and humidity), and MQ-135 (for air quality), and they provide constant and real-time measurements of their respective environments. They feed this information into the ESP32 microcontroller as their primary processing unit. The ESP32 reads the non-digital signal (voltage) each sensor produces and converts it into a digital representation of the value before passing the information on to the cloud.

Then, the processed information is transmitted to the cloud through Wi-Fi on the ESP32 to the Firebase Realtime Database where it is stored securely using SSL encryption. Any time the database is updated, the information is immediately available to all users regardless of their location. Users can access the recorded information through the Android app created using Java and XML, to get live updates regarding soil and environmental parameters from the mobile interface.
stop depending on sensor input.

Through the use of AI, the system not only tracks but also conducts analytical assessments of the data collected by AI gives the users the option to use an app to capture images of their plant foliage which sends back a response using a CNN model to determine what possible diseases may be present. In addition, it will take into account the AQI index to give her information about different air cleaning plants that will help with the air quality surrounding her crops. The combined functions of acting in the present with monitoring in real-time and being able to conduct AI analytical assessments will support the user in making timely decisions to improve the health and productivity of their crops.

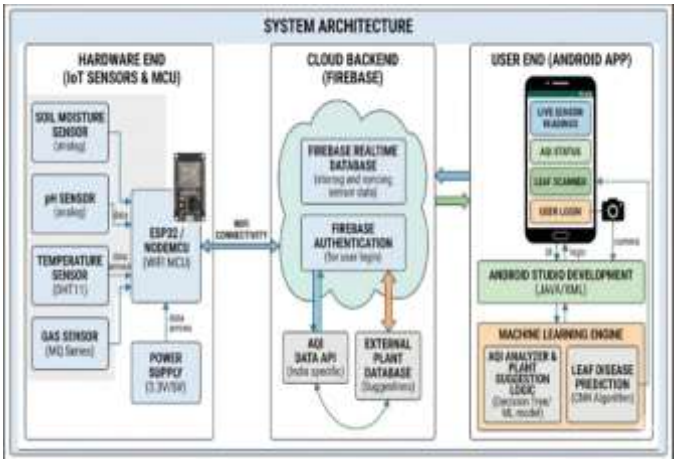

Fig -1: Figure

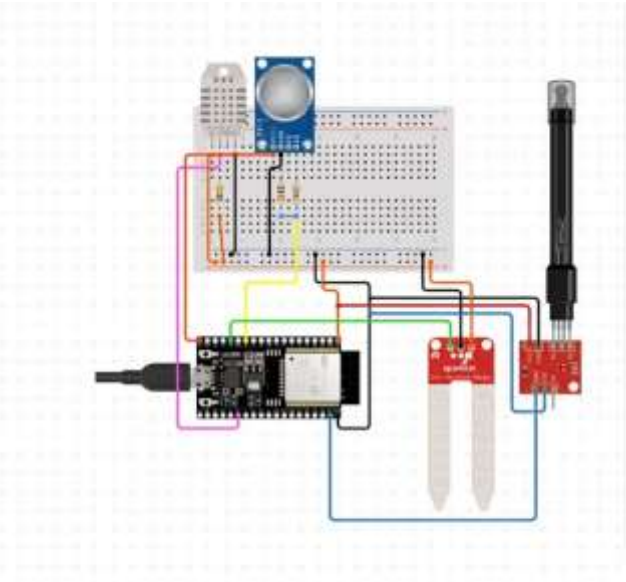

Fig -2: Figure

3. CONCLUSIONS

The Smart Soil Analyzer system is a perfect combination of IoT and AI to advance modern farming methods. Through the system, it is possible to monitor moisture, pH, temperature, and air quality in real-time so that users can make well-informed decisions about their crops based upon these six variables. Additionally, this system incorporates a CNN model for detecting plant disease early on; thus, reducing crop loss due to disease.

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