

Android Based Smart Agriculture App

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Abstract — India is an agricultural country where the agriculture sector is the backbone of the economy, contributing to more than 40% of the country's GDP [1]. The agricultural industry continues to struggle with various issues, including limited water availability, shifting climate patterns, and decreased yields caused by traditional and inefficient farming methods. Hence, it is essential to integrate advanced technologies into agriculture to improve efficiency and boost crop output. This project proposes an IoT-enabled Smart Agriculture Monitoring System designed to automate and streamline crop management for better productivity. System uses various sensors to monitor environmental conditions in real-time. The data collected is processed by a microcontroller and transmitted wirelessly to a web application that provides farmers with visualized information about their crops. This system is developed to be cost-effective and user-friendly, enabling farmers to remotely track crop conditions and make informed decisions to support optimal growth. The system delivers real-time insights into crop conditions, assisting farmers in making smart choices about irrigation, fertilizer application, pest management, and optimal harvesting periods. As a result, it can contribute to higher yields, lower expenses, and greater overall profitability. The project also has future implications, including the integration of machine learning and artificial intelligence technologies to further optimize crop management. With the increasing demand for food production this project offers a potential solution for promoting sustainable agriculture while tackling the pressing issues of climate change and food security.

Keywords: Agriculture, IoT-based Real-Time, Web App, ESP32, Temperature, Humidity, Moisture sensor, Fertilizer calculator, Image processing, Cloud

I. INTRODUCTION

Smart Agriculture combines advanced technologies with conventional farming methods to enhance efficiency, sustainability, and output. By leveraging IoT devices, sensors, AI, big data analytics, and automation, it allows for accurate monitoring and management of key agricultural activities. Agriculture serves as one of the most essential sectors in society, involving the cultivation of land, production of food crops, and fulfilling basic human needs. Smart agriculture leverages AI and IoT for cyber-physical farm management [1], enabling farmers to monitor climate factors, soil characteristics, soil moisture, and more in real time. The main idea of precision agriculture is to improve spatial management practices to increase crop production [11].

Shetkari Mitra is an innovative agriculture-based application designed to assist farmers in improving their crop productivity, managing soil health, and monitoring environmental conditions. The project integrates image

processing, machine learning, and IoT technologies to provide real-time insights and data-driven recommendations.

By leveraging modern technologies, Shetkari Mitra aims to empower farmers with precise agricultural guidance, ensuring sustainable farming practices and increased yields. Smart systems significantly improve the accuracy and efficiency of monitoring tools for plant growth and livestock management [2], [11]. Wireless Sensor Networks (WSNs) are employed to collect environmental data from various sensors, while cloud computing is integrated to remotely analyze and process this data—facilitating better decision-making [2], [11]. According to Farooq et al. (2020), effective farm management requires ICT tools, on-ground sensors, and automation through robots or autonomous devices [2].

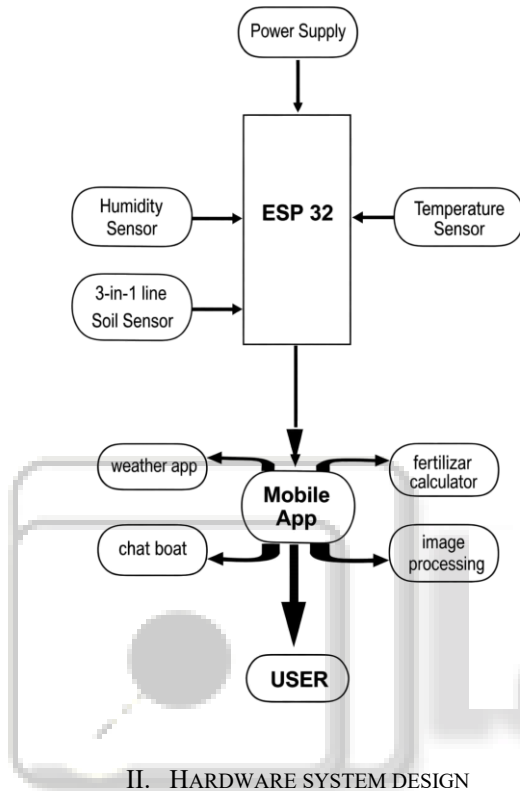
Shetkari Mitra primarily aims to create an intelligent agricultural system that can assess soil properties, track crop health, and forecast the requirements for fertilizers and pesticides. The application features image processing for detecting plant diseases, nutrient deficiencies, and other anomalies, while IoT-based sensors (MQ135 for air quality, DHT11 for temperature/humidity, and soil moisture sensors) provide continuous environmental data [2], [11]. The system also incorporates machine learning and data analysis to determine fertilizer requirements by evaluating soil composition and observing crop growth patterns [14], [19]. A user-friendly dashboard offers real-time insights and actionable recommendations for farmers [15].

The Shetkari Mitra project integrates IoT components like MQ135, DHT11, and soil moisture sensors for environmental monitoring. Crop health prediction and fertilizer estimation are carried out using machine learning algorithms. Leaf images are analyzed using image processing methods to detect diseases, complementing the application of deep learning techniques in agricultural disease diagnosis [9], [10]. The system's success is influenced by high-speed internet, mobile access, and satellite technologies, which help collect images and positioning data for real-time monitoring. For example, James et al. (2019) has showed real-time disease detection in banana and paddy fields was showcased by utilizing satellite images and sensor data, which were processed and communicated back to farmers through a web server. [11].

In Smart Agriculture Systems, Image Processing plays a crucial role. Drones or ground-based cameras capture images that are processed to evaluate soil texture, moisture levels, and plant health. This supports precision farming, helping farmers place seeds properly and plan irrigation [9], [10]. Visual features like color, shape, and texture are used to detect early signs of nutrient deficiencies or disease, enabling early intervention [9]. Advanced image acquisition techniques, including infrared and ultraviolet imaging, offer deeper insights into plant stress, water content, and nutrient status [9]. In image segmentation, clustering

based on color/texture separates crops from weeds—an essential function for automated weeding systems.

Shetkari Mitra is a smart agricultural companion that brings technology-driven solutions to traditional farming. By integrating IoT, image processing, and machine learning, it aims to revolutionize agricultural practices, enabling sustainable, precise, and data-driven farming. With the rise of precision agriculture, Shetkari Mitra serves as an effective solution for contemporary farmers, supporting a more intelligent and efficient future in agriculture. [14], [15], [19].



II. HARDWARE SYSTEM DESIGN

A. ESP32:

- It comes with integrated Wi-Fi and Bluetooth, which makes it ideal for IoT applications in agriculture, allowing real-time data transfer and remote monitoring without additional modules.
- It has multiple power-saving modes, which makes it suitable for battery-powered agricultural sensors that need to operate in the field for extended periods. The ESP32 has a dual-core processor and more memory compared to ESP8266 and most Arduino boards, making it well-suited for processing data from multiple sensors and handling tasks like image processing or complex data calculations.
- Offers a sufficient number of GPIO pins, ADC channels, and PWM outputs, making it ideal for projects that involve connecting multiple sensors like soil moisture, temperature and humidity, and air quality sensors.
- With its low power usage, integrated Wi-Fi and Bluetooth, strong processing capabilities, and affordability, the ESP32 is well-suited for IoT-based agricultural applications.

B. Temperature & Humidity Sensor:

- This device is used to take data about Temperature and Humidity. Temperature is Important factor when crops are beginning to be ready. When temperature exceeds the maximum level it will be dangerous for crops growth, health and Quality.
- The DHT-11 sensor is used to measure temperature and humidity by detecting environmental conditions. It collects analog data from its surroundings, which is then converted into digital signals by the microcontroller. This digital data is easier to process and transmit.
- The DHT11 digital sensor measures temperature and humidity, key factors in identifying the onset of crop growth or fruit development.

C. 3-in-1 Line Soil Sensor:

- The 3-in-1 Line Soil Sensor was chosen for its capability to simultaneously measure soil moisture, pH, and light intensity within a single compact unit.
- This sensor offers an all-in-one solution, making it highly suitable for agriculture where monitoring multiple soil factors is essential for maintaining crop health.
- Its easy integration with microcontrollers such as the ESP32 and straightforward calibration process further support its use in the project.

D. 16x2 LCD Display:

- An LCD 16x2 display is utilized in IoT-based smart agriculture systems to show real-time data like temperature, humidity, and soil moisture levels.
- This enables farmers to conveniently keep track of field conditions without needing to frequently access their devices. The 16x2 format of the LCD display allows for the display of two rows of 16 characters, providing ample space for displaying multiple pieces of information at once.
- Moreover, LCD displays have lower power consumption compared to other display types, making them ideal for remote, battery-operated monitoring setups.

III. METHODOLOGY

A. Hardware Layer:

- ESP32 Microcontroller: Collects and transmits sensor data.
- Sensors:
 - DHT11 for temperature and humidity.
 - MQ135 for air quality.
 - 3-in-1 Soil Sensor for pH, moisture, and light.
 - 16x2 LCD: Displays real-time data in the field.

B. Software Layer:

- Android App: Receives sensor data via Wi-Fi, displays it to users, and allows image uploads.
- Image Processing Module: Identifies plant diseases from uploaded images using CNN models.
- Fertilizer Calculator: Uses ML models to recommend optimal NPK levels based on sensor inputs and image data.

C. Cloud Integration:

- Real-time data logging and remote access.
- Enables collaboration and record-keeping.

D. Workflow:

- Login via app
- Upload crop image
- Image is processed
- Sensors collect field data
- Recommendations are provided based on inputs

IV. LITERATURE REVIEW

The literature survey presents a comprehensive view of recent advancements in smart agriculture, reflecting the wide array of technological interventions aimed at addressing the critical challenges in the agricultural sector. Each study introduces specific innovations that contribute uniquely to improving agricultural practices, whether through deep learning for disease detection, IoT for environmental monitoring, machine learning for forecasting, or mobile applications for soil analysis.

The 2022 study on Deep Learning-Based Leaf Disease Detection highlights the strong capability of convolutional neural networks, especially the DenseNet-121 model, in precisely diagnosing plant diseases from images. By fine-tuning DenseNet-121 alongside other prominent architectures such as ResNet-50, VGG-16, and Inception V4, this model achieved a remarkable classification accuracy of 99.81%, setting a high benchmark for automated disease detection. This accuracy highlights CNNs' ability to extract critical features from complex image data, making it possible to detect plant diseases with minimal manual intervention. Moreover, the approach is non-invasive, allowing farmers to analyze plant health without physically affecting the crops. However, the model's dependency on extensive, high-quality labeled datasets presents a substantial limitation. Gathering enough labeled data across a wide range of plant species, disease types, and environmental conditions is a time-consuming and resource-intensive task. Furthermore, the model's effectiveness is often limited to the specific plants and diseases it was trained on, restricting its transferability to other crops without substantial retraining efforts, which can be costly and labor-intensive.

The 2022 study titled 'Maize Leaf Disease Identification Based on Feature Enhancement and DMS-Robot Alexnet' takes a focused approach by concentrating exclusively on detecting diseases in maize leaves. The methodology combines dilated and multi-scale convolutions in the DMS-Robust Alexnet model to enhance feature extraction, providing the model with a unique capability to identify diseases in maize leaves with greater precision. Additionally, the incorporation of batch normalization reduces the risk of overfitting, thus enhancing the model's robustness and reliability. This crop-specific focus allows for high optimization levels, enabling the model to outperform more general models not tailored to specific plants. However, this specialization is also a limitation, as the model's design does not readily translate to other crops. Significant modifications or even retraining would be required to adapt this approach to other plant species. Another limitation is the

potential for overfitting caused by advanced feature extraction; without proper regularization, this can result in high accuracy during training but poorer performance when applied to varied real-world data.

The Internet-of-Things (IoT)-Based Smart Agriculture System (2021) takes a holistic approach by integrating IoT devices, sensors, and cloud computing to provide real-time monitoring and management of farming activities. This system involves using soil moisture sensors, climate stations, and smart irrigation systems, all connected to a central platform that analyzes and visualizes data for farmers. Real-time monitoring allows for optimized resource usage, such as water and fertilizers, which can significantly impact crop yields and reduce labor costs. Additionally, early detection capabilities help farmers proactively address issues like pest infestations and diseases before they spread. However, the system is hampered by high initial setup and operational costs, which can be prohibitive for small-scale farmers. Connectivity issues in rural areas, where internet access may be limited, also pose a challenge, as continuous data transmission and real-time monitoring rely on stable connections. Further, the reliance on cloud-based data processing raises security and privacy concerns, especially regarding sensitive agricultural data that could be vulnerable to cyber threats.

The Weather Forecasting Application (2021) and Weather Forecast Using Machine Learning (2020) studies both address the importance of accurate weather predictions for agriculture, which are crucial for planning planting, watering, and harvesting. The 2021 application employs a three-layer architecture that utilizes linear regression and decision tree regression for long-term forecasting, offering users insights based on historical weather data. This system's SQL database stores and processes weather parameters such as temperature, wind speed, rainfall, and humidity, with data sourced from the India Meteorological Department and APIs like Open Weather Map. The machine learning-based weather forecast system in 2020 uses linear regression and Naïve Bayes algorithms, trained on historical weather data from Kaggle, to predict weather patterns. By incorporating machine learning, this system offers improved accuracy and handles more complex weather parameters than traditional methods. Both approaches enable faster predictions and support agricultural decision-making. However, the accuracy of predictions in both studies depends heavily on data quality and the models used. The use of historical data in linear and basic machine learning models may limit their ability to fully capture complex, nonlinear weather patterns, such as sudden shifts due to climate change, making these systems potentially less effective in extreme or highly variable conditions.

The Modeling Soil Fertilizer Levels and Crop Yields Using Machine Learning (2020) project focuses on optimizing fertilizer use to enhance crop yields based on soil data. By predicting optimal fertilizer levels, this approach allows for efficient nutrient management tailored to specific soil characteristics, which can maximize yields and reduce excessive fertilizer application. The model's adaptability to real-time data makes it scalable across different regions, allowing farmers to make informed, data-driven decisions. Despite its benefits, this method requires high-quality

datasets and sophisticated models, both of which can be expensive to implement and maintain. Additionally, generalizing the model across various regions or crops remains challenging, as soil characteristics and fertilizer needs can differ greatly depending on local conditions.

Finally, the Evaluation of Mobile Applications for Estimating Soil Properties (2019) provides insights into the current capabilities of mobile apps that estimate soil properties. This study evaluated 32 soil analysis applications based on app ratings and functionality, identifying high-ranking apps and offering design recommendations for future development. These applications offer an automated means of estimating soil properties using smartphones, making soil analysis more accessible to farmers and agricultural consultants. The study reveals that while these applications show promise, many lack evidence-based validation, which limits their reliability. Additionally, the functionality is often limited, with few customization or data export options, which restricts the user's ability to adapt the application to specific needs.

V. CONCLUSION & FUTURE SCOPE

In summary, the IoT-based smart agriculture monitoring system presents an efficient and practical approach for farmers to oversee and enhance crop growth. By gathering and analyzing data on key environmental parameters like temperature, humidity, soil moisture, and light intensity, the system equips farmers with crucial information about crop health and development. Utilizing various sensors, it can identify issues such as pests, diseases, and nutrient shortages early, enabling timely interventions. Additionally, the system supports the automation of tasks like irrigation and fertilization, helping save time and resources while boosting overall crop productivity.

A. Future Scope

1) Integration with Advanced Sensors:

- Soil Moisture Sensor: Helps determine the exact water requirements of crops, leading to efficient irrigation.
- pH Sensor: Measures soil acidity and alkalinity, assisting in selecting the right fertilizers.
- NPK Sensor: Analyzes soil nutrient levels (Nitrogen, Phosphorus, and Potassium) and recommends fertilizers accordingly.
- CO₂ and Air Quality Sensors: Monitor air pollution levels and their impact on crops.
- Rain Sensors: Predict rainfall, helping farmers in water conservation and crop protection.

2) AI-Powered Predictive Analysis:

- Crop Disease Forecasting: Using historical data, AI can predict potential outbreaks of diseases and suggest preventive measures.
- Weather Pattern Predictions: AI models can analyze climate trends and predict extreme weather conditions like droughts and heavy rainfall.
- Yield Prediction Models: Based on soil fertility, weather, and farming techniques, ML algorithms can estimate expected crop yields.

3) Cloud-Based Data Storage and IoT Connectivity:

- Store historical agricultural data for long-term analysis.
- Enable real-time data access from any location.
- Provide secure and scalable storage, ensuring data is not lost.
- Allow multiple users (farmers, researchers, and agricultural experts) to collaborate and share insights.
- Weather Pattern Predictions: AI models can analyze climate trends and predict extreme weather conditions like droughts and heavy rainfall.

4) Smart Irrigation System:

- Soil moisture levels are monitored in real-time.
- Water pumps are automatically turned on/off based on soil moisture levels
- Farmers receive alerts and suggestions on optimal watering schedules.
- Water conservation is achieved, reducing wastage and improving efficiency.

5) Blockchain for Secure Agricultural Transactions:

- Direct transactions between farmers and buyers, eliminating middlemen.
- Smart contracts for automated payment settlements.
- Tamper-proof records of crop quality, pricing, and supply chain management.
- Fair pricing models for farmers, ensuring they receive competitive market rates.

6) Drone-Based Crop Monitoring:

- Capture high-resolution images for disease detection.
- Provide NDVI (Normalized Difference Vegetation Index) analysis for assessing plant health.
- Perform precision spraying of pesticides and fertilizers, reducing wastage and improving efficiency.
- Cover large farmlands quickly, reducing manual labor.

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