DESIGN AND DEVELOPMENT OF INTERNET OF THINGS (IOT) BASED SMART AGRICULTURAL SYSTEMS

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ABSTRACT

This paper presents an Internet of Things (IoT) based system by designing a novel Nitrogen PhosphorusPotassium (NPK) sensor with Light Dependent Resistor (LDR) and Light Emitting Diodes (LED). The principle of colorimetric is used to monitor and analyze the nutrients present in the soil. The data sensed by the designed NPK sensor from the selected agricultural fields are sent to Google cloud database to support fast retrieval of data. The concept of fuzzy logic is applied to detect the deficiency of nutrients from the sensed data. The crisp value of each sensed data is discriminated into five fuzzy values namely very low, low, medium, high and very high during fuzzification. A set of If-then rules are framed based on individual chemical solutions of Nitrogen (N), Phosphorous (P) and Potassium (K). Mamdani inference procedure is used to derive the conclusion about the deficiency of N, P and K available in soil chosen for testing and accordingly an alert message is sent to the farmer about the quantity of fertilizer to be used at regular intervals. The proposed hardware prototype and the software embedded in the microcontroller are developed in Raspberry pi 3 using Python. The developed model is tested in three different soil samples like red soil, mountain soil and desert soil. It is solution observed that the developed system results in linear variation with respect to the concentration of the soil. A sensor network scenario is created using Qualnet simulator to analyze the performance of designed NPK sensor in terms of throughput, end to end delay and jitter.

Key Word

- Internet of Things (IoT)
- Smart Agriculture
- Precision Farming
- Sensor Networks
- Data Analytics
- Remote Monitoring
- Agricultural Sensors
- Soil Moisture Monitoring

I INTRODUCTION

Agriculture in India has become volatile, with a growth rate of 2.9% in 2019-2020. Challenges include inconsistent monsoons, limited irrigation, excessive fertilizer use, and lack of modern technology. Soil fatigue results from improper fertilizer application, highlighting the need for farmers to understand soil nutrients for better yields. Soil testing is essential for crop selection, nutrient management, and cost reduction, yet many farmers avoid it due to high costs. This leads to improper fertilizer use and crop damage. Nutrients are classified into macronutrients (e.g., Nitrogen, Phosphorus) and micronutrients (e.g., Iron, Zinc), each varying in requirement by plant type.

II LITERATURE REVIEW

A literature review on the design and development of Internet of Things (IoT) based smart agricultural systems provides a comprehensive overview of current research, trends, and technologies that shape this rapidly evolving field. This review highlights the significance of IoT in agriculture, key components of smart agricultural systems, recent advancements, and the challenges faced in implementing these technologies. The Internet of Things (IoT) refers to a network of interconnected devices that communicate and exchange data over the internet. In agriculture, IoT technologies enable real-time monitoring and management of farm activities, leading to improved efficiency, productivity, and sustainability.

III EXISTING SYSTEMS

1. Smart Irrigation Systems

Smart irrigation systems utilize soil moisture sensors, weather data, and IoT technologies to automate and optimize irrigation schedules. These systems help conserve water and improve crop yield by delivering the right amount of water at the right time.

2. Livestock Monitoring Systems

These systems employ wearable sensors and GPS tracking devices to monitor the health, location, and behavior of livestock. This technology enables farmers to manage their herds more effectively.

3. Drones in Agriculture

Drones are used for aerial surveillance of crops, allowing for large-scale monitoring of agricultural fields. They can capture high-resolution images and gather data for analysis.

IV DISADVANTAGES

1. High Initial Costs

Implementing IoT solutions in agriculture can require a significant upfront investment. Costs associated with purchasing sensors, drones, and other IoT devices, as well as installation and maintenance, can be prohibitive, particularly for small-scale farmers or those in developing regions. The financial burden may deter adoption, especially when immediate returns on investment are not guaranteed.

2. Connectivity Issues

Many agricultural operations are located in rural areas where internet connectivity can be limited or unreliable. This lack of reliable network access can hinder the performance of IoT devices, which rely on continuous data transmission to function effectively. Without stable connectivity, the benefits of real-time monitoring and automation are diminished.

3. Data Privacy and Security Concerns

The collection and transmission of data via IoT devices raise significant privacy and security issues. Farmers may be concerned about unauthorized access to sensitive information regarding their operations, crop yields, and financial data. Cybersecurity threats, including hacking and data breaches, pose risks to both individual farms and the broader agricultural supply chain.

4. Complexity and Technical Challenges

The integration of various IoT devices and platforms can be complex, requiring technical expertise that many farmers may lack. Managing multiple systems, ensuring compatibility, and troubleshooting issues can be daunting. Additionally, the need for continuous updates and maintenance can add to the operational complexity.

5. Interoperability Issues

IoT devices and systems from different manufacturers may not communicate effectively due to varying standards and protocols. This lack of interoperability can complicate data sharing and integration, limiting the overall effectiveness of smart agricultural solutions. Farmers may face challenges in consolidating data from different sources into a unified platform for analysis.

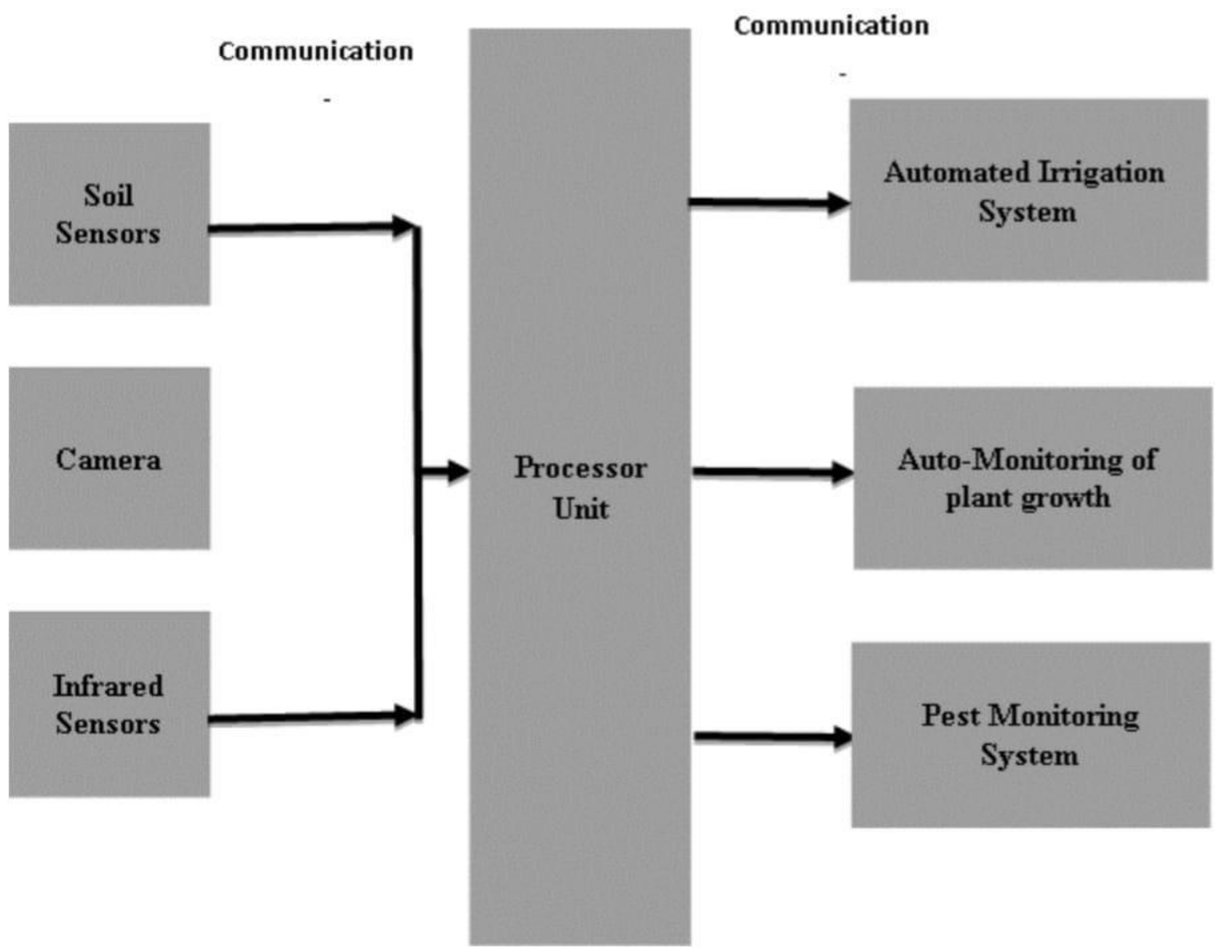
6. Reliance on Technology

Over-reliance on IoT technology can lead to challenges in traditional farming practices. Farmers may become too dependent on automated systems and neglect essential skills related to crop management and animal husbandry. In situations where technology fails or is compromised, farmers may struggle to make decisions without the insights provided by IoT systems.

7. Environmental Impact of Technology

While IoT systems can promote sustainable practices, the production and disposal of electronic devices can have environmental repercussions. The manufacturing processes often involve resource-intensive activities, and improper disposal of electronic waste can lead to pollution and harm to ecosystems.

V BLOCK DIAGRAM



VI PROPOSED METHODOLOGY

The proposed presents an IoT-based system featuring a novel Nitrogen Phosphorus-Potassium (NPK) sensor using Light Dependent Resistors (LDR) and Light Emitting Diodes (LED) based on colorimetric principles. The sensor monitors soil nutrients, with data sent to a Google Cloud database for quick retrieval. Fuzzy logic detects nutrient deficiencies by categorizing sensed data into five levels: very low, low, medium, high, and very high. A Qualnet simulator creates a sensor network scenario to evaluate the NPK sensor's performance in terms of throughput, end-to-end delay, and jitter. The IoT system aids farmers in achieving higher crop yields

VII ADVANTAGES

1. **Enhanced Resource Management**

IoT systems enable precise monitoring of resources, such as water, fertilizers, and pesticides. By using data from soil moisture sensors and weather forecasts, farmers can optimize irrigation schedules, reducing water wastage and minimizing the environmental impact.

2. **Improved Crop Monitoring**

Continuous real-time monitoring of crop conditions, including soil health and moisture levels, allows farmers to make informed decisions. IoT devices can detect changes in crop health early, enabling timely interventions to prevent diseases or pest infestations.

3. **Increased Yield and Quality**

With access to real-time data and analytics, farmers can implement better farming practices tailored to specific crop needs. This can lead to increased yields and improved crop quality, as interventions can be precisely timed and targeted.

4. **Cost Savings**

By automating irrigation and resource application based on actual needs rather than fixed schedules, farmers can significantly reduce operational costs. Reduced water, fertilizer, and labor costs can enhance profitability.

5. **Data-Driven Decision Making**

IoT systems provide valuable insights through data analytics. Farmers can analyze historical data to understand trends, forecast yields, and optimize planting schedules, leading to more informed and strategic decision-making.

VIII APPLICATIONS

1.Automatic irrigation control:

Effective usage of water in farming by monitoring soil condition and automate the activation of sprinklers.

2.Arable farming:

It includes soil condition monitoring, analysis for pest and disease detection, machine and agricultural semi- automated (drones) and fully automated vehicle (bot) monitoring and control.

3.Cattle and animal welfare:

It includes movement monitoring to identify and prevent diseases such as lameness and behaviour monitoring.

4.Greenhouse and indoor horticulture:

This system monitors environmental factors to ensure prime atmospheric conditions are preserved throughout the year.

IX FUTURE SCOPE

The future scope of IoT-based smart agricultural systems is promising and multifaceted, driven by advancements in technology, increasing global food demands, and a growing emphasis on sustainability The incorporation of artificial intelligence (AI) and machine learning (ML) into

IoT agricultural systems will enable more sophisticated data analysis. Predictive analytics can help farmers anticipate crop diseases, optimize yields, and make better planting and harvesting decisions IoT systems will play a crucial role in helping farmers adapt to climate change by providing real-time data on weather patterns and soil conditions. Future developments may include more sophisticated weather forecasting tools and climate-smart agriculture practices that optimize resource use and reduce greenhouse gas emissions**.** The integration of smart agricultural practices with smart city initiatives will promote urban agriculture and local food production.

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