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BAGONG PILIPINAS

Smart IoT Greenhouse System: Automated Climate Control, Irrigation, and CNN-Based NPK Health Monitoring for Lettuce

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CHAPTER I

Project Context

Farming today faces many challenges, from changing weather conditions to the need for better ways to use limited resources. Greenhouses have become a valuable solution by offering a controlled environment for growing crops, but traditional greenhouses often require a lot of hands-on work to manage temperature, humidity, irrigation, and other factors. This can be tiring, time-consuming, and leaves room for mistakes.

The Smart IoT Greenhouse System: Automated Climate Control, Irrigation, and CNN-Based NPK Health Monitoring for Lettuce was designed to make greenhouse farming easier and more efficient. It uses advanced technologies like the Internet of Things (IoT) and Convolutional Neural Networks (CNNs) to automate important tasks like adjusting the climate, watering the plants, and monitoring their nutrients. With sensors gathering real-time data and AI detecting nutrient issues, farmers can ensure their lettuce grows in the best conditions with less effort.

A simple web interface allows farmers to manage their greenhouse remotely, so they don't have to be there all the time. If something goes wrong—like a sudden drop in temperature or a nutrient imbalance—the system sends alerts to notify them right away, helping prevent problems before they get worse.

This project is more than just a tool for growing lettuce; it's a step forward in making farming smarter, more sustainable, and easier for everyone. By combining technology with traditional farming practices, it opens up opportunities for better productivity, more efficient resource use, and a brighter future for agriculture.

Objectives of the Study

The general objective of Smart IoT Greenhouse System: Automated Climate Control, Irrigation, and CNN-Based NPK Health Monitoring for Lettuce, is to develop an IoT-based greenhouse system for optimized lettuce growth. By developing this is not just to optimizes the lettuce growth but also helps by monitoring the greenhouse even in distance.

While in Specific Objectives are:

1. Automate climate control (temperature, humidity, light) and irrigation system.
2. Implement image-based nutrient deficiency detection for monitoring.
3. Deploy website as user interface for managing the greenhouse
4. Implement an alert system for anomalies within the system, climate, or nutrient.

Scope and Limitations of the Study

This project focuses on developing a Smart IoT Greenhouse System for optimal lettuce growth. The study aims to automate climate control, including temperature, humidity, light intensity, and irrigation, based on defined parameters and real-time sensor data. Imagine a system that automatically adjusts the environment to meet the lettuce plants' needs, ensuring optimal growth conditions. A user-friendly web-based platform will be developed for remote monitoring and management of the greenhouse system. Additionally, the system will utilize CNN-based NPK health monitoring, allowing it to "see" the lettuce plants and identify any signs of nutrient deficiencies (Nitrogen,

Phosphorus, Potassium), enabling targeted interventions to prevent further damage.

However, limitations exist, including technical failures such as power outages, network connectivity issues, and sensor malfunctions, which can impact data collection and system performance. Furthermore, the initial cost of implementing IoT devices, sensors, and web hosting may be high, potentially limiting accessibility for smaller farming operations.

Significance of the Study

The Smart IoT Greenhouse System: Automated Climate Control, Irrigation, and CNN-Based NPK Health Monitoring for Lettuce brings a fresh and innovative approach to farming. By blending advanced IoT and AI technologies with traditional agricultural methods, it offers practical and sustainable solutions that address the everyday challenges faced by modern farmers. This project not only makes farming smarter and more efficient but also creates opportunities to grow crops in a way that’s more mindful of resources, making it a meaningful step forward for both farmers and the environment.

The study will be considered beneficial to the following:

For Farmers: This system transforms farming as we know it. It takes care of essential tasks like adjusting temperature, humidity, and irrigation automatically, so farmers don't have to do it all by hand. With remote monitoring, they can keep an eye on their greenhouses from anywhere, saving time and effort. Plus, the system's real-time alerts help them tackle problems like nutrient deficiencies or climate issues quickly, ensuring their crops stay healthy and productive. This is especially helpful for small and urban farmers who need to get the most out of their limited time and resources.

For Agricultural Researchers: This project is a game-changer for agricultural science. It shows how technologies like IoT and AI can be used to make farming smarter and more efficient. Researchers can build on this system to explore ways to grow other crops, predict yields more accurately, or solve even bigger farming challenges with AI. It's a practical step forward for anyone studying how to make agriculture better using modern tools.

For the Academic Community: This project isn't just about farming it's about showing how technology can solve real-world problems. For students and teachers, it's a great

example of how IoT, machine learning, and hardware can work together. It also encourages collaboration across fields like IT, environmental science, and agriculture. It's the kind of project that sparks ideas and inspires others to think creatively about how to use technology in new and meaningful ways.

For the Environment: The system is a win for sustainability. By using resources like water and energy more efficiently, it helps conserve what's most precious. It also reduces over-fertilization by identifying exactly what the plants need, cutting down on harmful environmental impacts. Automation ensures resources are only used when necessary, making farming not just smarter, but greener too.

For Local and Global Communities: Locally, this project gives rural farmers access to high-tech tools they might not have had before. It can boost their productivity, help their businesses grow, and improve their livelihoods. On a global scale, it supports efforts to fight hunger and manage resources responsibly. By improving the way we grow food, it helps address big challenges like food security and sustainability.

For Technology Enthusiasts and Innovators: This project is a showcase of what's possible with emerging tech. It's an

inspiring example for anyone who loves creating and problem-solving. Whether it's adapting the system for other types of farming or using its ideas in entirely different fields, it proves that combining tools like IoT, AI, and cloud platforms can lead to big, impactful innovations.

Conceptual Framework

INPUT

Sensors:

Light Intensity (Light Sensor Module)

Temperature & Humidity (DHT22)

Soil Moisture (Soil Moisture Sensor)

Lettuce Image (Esp32-Cam)

Website:

Light Intensity Threshold

Temperature & Humidity Threshold

Soil Moisture Threshold

Device Configuration

Image-based Lettuce NPK Deficiency Detection:

Healthy Lettuce Images

Nitrogen Deficient Lettuce Images

Phosphorus Deficient Lettuce Images

Potassium Deficient Lettuce Images

PROCESS

Data Collection:

Sensors collects environment data such as light intensity, temperature, humidity, soil moisture, and an image of lettuce.

These data are transmitted to the gateway which will be the Esp32 and then uploaded online to an API all via HTTP.

User Interaction:

The user modifies thresholds according to their needs.

The user manually controls the actuators.

Data Processing:

The model is trained with Healthy and NPK deficient datasets.

The server compares collected data with the set thresholds.

The server using a trained model identifies healthy and NPK deficient lettuce plants from the image sent.

OUTPUT

Visualization of current and historical environment data.

Log and storage of environmental data collected.

Remote monitoring of greenhouse climate through sensors.

Remote controlling of greenhouse climate through actuators.

Automated climate control by the rules set by the thresholds modified by the owner.

Achievement of efficiency with measured usage of resources through IoT devices.

Accurate detection of nutrient deficiency in lettuce plants through image.

Alerts for quick action with environmental anomalies in the greenhouse and detection of nutrient deficiency.

Definition of Terms

NPK (Nitrogen, Phosphorus, Potassium): Essential macronutrients for plant growth.

User interface: A platform for users to monitor and control the greenhouse system remotely.

Alert system: A mechanism to notify users of anomalies in climate conditions, nutrient levels, or system malfunctions.

IoT (Internet of Things): A network of connected to devices that collect and exchange data through the internet.

Alert system: A mechanism to notify users of anomalies in climate conditions, nutrient levels, or system malfunctions.