

Raspberry Pi Pico Based IoT Green House Monitoring and Controlling System

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Abstract: *The Raspberry Pi Pico Based IoT Greenhouse Monitoring and Controlling System is designed to automate and optimize environmental conditions for plant growth using smart technology. The system employs multiple sensors such as temperature, humidity, soil moisture, and light intensity sensors to continuously monitor greenhouse parameters. These real-time data are processed by the Raspberry Pi Pico microcontroller, which controls various loads like fans, water pumps, and lights to maintain ideal growing conditions. The IoT integration enables remote monitoring and control via a cloud platform or mobile application, providing users with real-time alerts and data visualization. This approach minimizes manual intervention, enhances energy efficiency, and ensures consistent crop yield. Overall, the project demonstrates an affordable and efficient solution for modern precision agriculture through sensor-based automation and IoT connectivity.*

Keywords: Raspberry, IoT, Humidity, Temperature etc

I. INTRODUCTION

This project “Greenhouse monitoring using Raspberry Pi” offers a sophisticated solution for enhancing agricultural practices through IOT technology. Employing a Raspberry Pi as the central processor, the system utilizes various sensors to monitor crucial environment parameters within the greenhouse. For instance, an LDR sensor is employed to measure light intensity, triggering the activation of LEDs if the intensity fails below a predefined threshold. Additionally, a DHT11 sensor is employed to monitor temperature levels, activating a CPU fan to mitigate overheating conditions if the temperature exceeds a set threshold. Furthermore, a moisture sensor is utilized to gauge soil moisture levels, activating a pump to irrigate the crops if moisture levels drop below a specified threshold.

The integration of these sensors and actuators enables the automated regulation of environmental conditions within the greenhouse, ensuring optimal growth conditions for cultivated crops. Moreover, the system incorporates advanced functionality to provide real-time alerts and notifications to greenhouse operators. Whenever environmental parameters surpass predefined thresholds, the system generates email alerts, enabling timely intervention and remedial action. This feature empowers greenhouse operators to promptly address any deviations from ideal conditions, thereby minimizing the risk of crop damage or loss. Furthermore, the ability to remotely monitor greenhouse conditions via email alerts enhances operational efficiency and enables proactive management of greenhouse operations. Overall, the Greenhouse monitoring system leveraging Raspberry Pi technology offers a comprehensive solution for optimizing crop cultivation practices, promoting sustainable agriculture, and maximizing yields. The Raspberry Pi Pico Based IoT Greenhouse Monitoring and Controlling System is an advanced automation project designed to improve agricultural productivity through smart technology.

In traditional greenhouses, maintaining optimal environmental conditions such as temperature, humidity, soil moisture, and light requires constant human attention. This system overcomes that limitation by using the Raspberry Pi Pico microcontroller along with multiple sensors to automatically monitor and regulate these parameters. The sensors collect real-time data on environmental factors, which the Pico processes to control various loads like exhaust fans, water pumps, and artificial lights. Through IoT connectivity, the system allows users to remotely monitor conditions and



control devices using a web or mobile interface. This helps in conserving resources like water and electricity while ensuring plants grow in ideal conditions. Overall, the system provides a cost-effective, energy-efficient, and scalable solution for smart greenhouse management, integrating automation with the Internet of Things to support sustainable farming practices.

OBJECTIVE

- To continuously monitor key environmental parameters like temperature, humidity, soil moisture, and light intensity.
- To automate the control of greenhouse devices such as fans, pumps, lights, and heaters based on sensor feedback.
- To provide real-time data visualization and remote monitoring through IoT connectivity.
- To reduce manual labor and improve precision in greenhouse management.
- To ensure optimal growing conditions for plants to enhance yield and quality.
- To design a cost-effective and energy-efficient smart greenhouse solution using Raspberry Pi Pico.
- To enable data logging for future analysis and performance tracking.
- To develop a scalable system that can integrate additional sensors or loads easily.
- To allow users to remotely control and configure greenhouse settings via a web or mobile dashboard.
- To promote sustainable farming by minimizing water and energy wastage through intelligent automation.

II. LITERATURE REVIEW

K. Patel (2017) et al. Comprehensive review that categorizes greenhouse automation architectures (centralized PLC, microcontroller-based, distributed WSN) and highlights common sensors (temperature, RH, soil moisture, CO₂, light) and actuators (fans, vents, heaters, irrigation valves). Emphasizes communication stacks (Zigbee, Wi-Fi, GSM, LoRa) and cloud platforms (Thing Speak, AWS IoT). Discusses control strategies (schedule, threshold, PID, fuzzy logic) and notes gaps: energy-efficient nodes, security, and integration of predictive analytics. Useful for mapping component-level design choices.

S. Ahmed (2018) et al. Prototype system using Arduino Uno, DHT22, soil moisture probes, and relay-controlled irrigation and fans. Data are published to ThingSpeak (MQTT/HTTP) for monitoring and simple threshold-based control. The paper reports reduced water use and better temperature stability in short tests. Limitations include single-site validation and minimal fault tolerance; the authors recommend adding local control fallback and calibrating sensors for long-term drift.

L. Zhang & M. Kumar (2016) et al. Field deployment of WSN nodes (Tiny OS/ Mote platforms) inside a commercial greenhouse to measure microclimate variability. Key findings: spatial gradients (temp/humidity) can be large even within small greenhouses, necessitating multiple sensors for robust control. Discusses energy- saving MACs and sleep schedules to extend battery life and tradeoffs between sampling frequency and control performance.

P. Gomez (2019) et al. Integrates fuzzy logic controller running on Raspberry Pi with cloud-based dashboard. Fuzzy rules fuse temperature, humidity, and soil moisture to modulate ventilation and irrigation. Demonstrated smoother responses and fewer on/off cycles than threshold control; authors report improved crop growth metrics (leaf area, biomass) in greenhouse trials. Notes complexity in membership tuning and proposes adaptive fuzzy tuning in future work.

N. Singh (2020) et al. Proposes layered architecture: sensor/actuator layer (edge nodes), gateway (edge analytics), cloud for storage/ML and user interface. Uses MQTT for telemetry, Dockerized micro services, and a REST API. Demonstrated predictive irrigation scheduling with machine learning on cloud reduced water use by 18%. Emphasizes scalability but flags network reliability and latency for closed-loop control as concerns.

R. Oliveira & H. Chen (2019) et al. Presents battery-powered sensor nodes using LoRa WAN for long-range, low-power telemetry. Focuses on periodic reporting for climate monitoring and uses a local gateway to trigger irrigation via



SMS. Benefits include long battery life and reduced wiring; limitations: low data rates unsuitable for image-based disease detection and potential duty-cycle issues in high-sample-rate needs.

M. Al-Turki (2021) et al. Argues for shifting control algorithms to edge gateways to avoid cloud latency. Implements local PID and anomaly detection on an ARM-based gateway, while cloud handles historical analytics. Shows reduced actuator latency and improved resilience to internet outages. Recommends hybrid designs combining edge for safety-critical loops and cloud for heavy analytics.

J. Park & S. Lee (2020) et al. Compares ARIMA, random forest, and LSTM models for short-term temperature/humidity forecasting using IoT time series. LSTM performs best for non-linear dynamics; authors propose forecast-driven control (pre-ventilation) to smooth climate swings. Notes requirement of extensive labeled data and computational cost for deep models, suggesting transfer learning for new sites.

A. Banerjee (2018) et al. Integrates EC (electrical conductivity), pH, soil moisture sensors and flow sensors to control fertigation. Cloud-based nutrient scheduling uses crop growth stage rules and real-time sensor feedback. Trials show more consistent nutrient delivery and reduced nutrient wastage. Points out sensor fouling and calibration as practical hurdles.

E. Morales & D. Sun (2019) et al. Uses cameras at canopy level to detect leaf spot and early blight via CNNs running on an edge GPU; detections are sent via MQTT to the farm management dashboard to trigger localized fungicide application. Demonstrates high detection accuracy in controlled datasets; challenges include variable lighting, occlusions, and the need for labeled datasets across crops.

F. Habib & R. Tan (2021) et al. Survey of attack vectors (MITM, false data injection, device compromise) and proposed mitigations (mutual TLS, hardware root of trust, secure boot, anomaly detection).

III. EXISTING SYSTEM

The existing system for greenhouse automation comprises of three main components: the HSM 20G humidity sensor module with signal conditioning circuit, the PIC18F452 microcontroller, and the ZigBee transceiver present at both the transmitting and receiving ends. At the receiving end, the ZigBee module is connected to a host computer for continuous monitoring and database maintenance. Wireless communication with simple hardware and user-friendly software, such as Labview, has been demonstrated as an efficient solution for automated greenhouse management in agriculture.

The approach allows for monitoring and control of climate and irrigation systems, making it a valuable tool in high-tech agriculture. Although the experimental results have been shown for two parameters, the system is scalable and can be extended to monitor and control additional parameters. The proposed approach has the potential for remote crop monitoring and control using Wireless Sensor Network (WSN) technology for large-scale greenhouses. The system is user-friendly, low-cost, and easily implementable, making it a promising solution for modern greenhouse automation.

Disadvantages

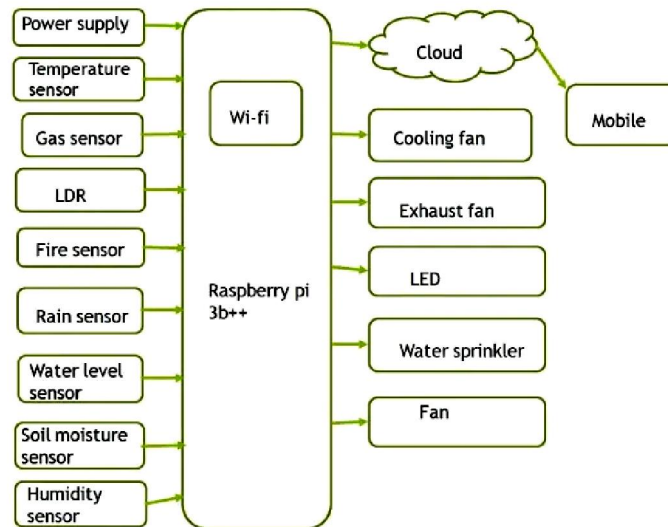
- Can be expensive to build.
- Can be expensive to heat.
- Requires constant monitoring, maintenance and care.
- Could increase electrical and water bills.
- May detract from aesthetic appeal of a garden.

IV. PROPOSED METHOD

This project is designed to monitor and control the greenhouse environment using IoT and Arduino. Four sensors are used to detect the temperature, light, humidity, and soil moisture inside the greenhouse. The temperature sensor detects the temperature, and if it goes above or below the threshold value, a signal is sent to the microcontroller. The microcontroller is connected to relays, and one of them is connected to a blower to turn on the fan if necessary. The light sensor detects the amount of sunlight, and if it is above the threshold value, a signal is sent to the microcontroller



to turn on the relay that would reduce the amount of sunlight. Similarly, the humidity sensor and soil moisture sensor are used to detect the humidity level and soil moisture, respectively. If the humidity value or soil moisture decreases, the microcontroller would turn on a DC motor in place of a blower and water outlet to decrease the humidity or increase the soil moisture.



Data from these sensors are sent to the IoT module (ESP8266) at regular intervals, and the ESP8266 chip is used to connect the microcontroller to the Wi-Fi network and send data. It also allows TCP/IP connections to be made. The project requires a Wi-Fi module to be connected to a Wi-Fi zone or hotspot. In the absence of the IoT module, a GSM module can be used to trigger an SMS. This project is user-friendly, low-cost, and can be easily implemented, making it ideal for greenhouse monitoring and control using IoT and Arduino technology.

Advantages

- This system helps in monitoring and controlling the climatic conditions that are favorable for the cultivation of a particular plant.
- By using this system, crop growth can be improved along with maximized yield, irrespective of the weather conditions.
- This project can be further enhanced to monitor and control the pesticide level

V. CONCLUSION

In conclusion, the greenhouse monitoring using Raspberry pi offers a efficient solution for monitoring and controlling environmental conditions crucial for plant growth. The ability to remotely monitor and control the greenhouse environment through the Raspberry Pi enhances convenience and flexibility for growers. Additionally, the system's scalability allows for the integration of additional sensors or devices to further improve monitoring and automation capabilities. Overall, this project demonstrates the potential of using Raspberry Pi for greenhouse management, offering an accessible and customizable solution for growers looking to enhance their agricultural practices using alert notifications to the users. And using cloud services like thing speak it provides an efficient real time monitoring. Additionally we can monitor using an android application known as thing view which can be easily used in android devices.

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