SmartGarden: An Economical IoT-Enabled System for Indoor Plant Surveillance and Irrigation

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ABSTRACT

SmartGarden is a low-cost IoT system for automating indoor plant care. It combines an ESP32 microcontroller with soil moisture, light, humidity, water level, and an air quality sensors to monitor plant conditions and control a water pump for irrigation. The device communicates via HTTP with an ASP.NET Core backend and a .NET MAUI mobile app, supporting offline-first functionality so that watering can occur even without internet. Users can set moisture thresholds and choose automatic or manual watering modes, and sensors can be calibrated for accuracy. In a two-week evaluation on peace lily and monstera plants, SmartGarden maintained healthy soil moisture levels and timely irrigation, demonstrating improved plant well-being with minimal user intervention.

CCS CONCEPTS

•Computer systems organization → Embedded systems;

• Hardware → Sensor devices and platforms;

• Applied computing → Agriculture.

KEYWORDS

IoT, smart irrigation, indoor plant monitoring, sensor calibration, mobile application

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1 Introduction

Indoor plants require regular watering and monitoring, yet busy owners often forget or lack expertise. IoT-based solutions can address this by automating plant care. Prior systems have used devices like Raspberry Pi or Arduino-family microcontrollers with sensors to monitor soil and trigger irrigation. These IoT systems reduce manual effort and can improve plant health and resource use. However, many are costly or rely on constant cloud connectivity. SmartGarden aims to provide an affordable, reliable alternative. It leverages a low-cost ESP32 controller and common sensors to keep indoor plants healthy. Unlike cloud-dependent designs, it runs offline first: the plant will be watered on time even if the network is down. Users can view data and control the system through a mobile app at their convenience.

2 System Architecture

SmartGarden's hardware unit centers on an ESP32 microcontroller connected to a soil moisture sensor, light sensor, temperature/humidity sensor, ultrasonic water-level sensor, and an MQ-135 gas sensor. A small pump waters the plant when activated. The ESP32 sends sensor readings to an ASP.NET Core backend via Wi-Fi (HTTP REST) whenever a connection is available. A .NET MAUI mobile app retrieves this data and allows user input. Crucially, the ESP32 contains the logic to compare soil moisture against a threshold and drive the pump accordingly, so automatic irrigation works even if the device is offline. The backend simply logs data and facilitates remote access, while the real-time control loop resides on the device. This design ensures that plants are cared for continuously, with the cloud used for data visualization and command input. The mobile app displays live sensor values (or last synced values offline) and lets users toggle modes or send a manual watering command, which the ESP32 executes upon receipt.

3 Key Features

The SmartGarden system integrates several functionalities that collectively enhance indoor plant care. It employs economical hardware, relying on an inexpensive ESP32 microcontroller and widely available sensors, which makes the solution budget-friendly while maintaining reliable performance. A core advantage of the design is its offline first automation: all watering decisions are executed locally on the device, with data buffered and synchronized to the server once connectivity is available, ensuring that irrigation continues uninterrupted during network losses. The system supports both automatic and manual irrigation modes; in automatic mode, the pump activates whenever soil moisture drops below a defined threshold, whereas in manual mode users can directly control watering through the mobile app, enabling one-click intervention when desired. To further improve accuracy and adaptability, SmartGarden offers sensor calibration routines, such as establishing a zero-point for the moisture sensor, allowing the system to be tailored to different soil conditions. In addition, the app delivers alerts whenever critical thresholds are exceeded, for instance, when the water tank is low or when poor

air quality is detected—so that users can take timely corrective action.

4 Evaluation and Results

We deployed SmartGarden on a peace lily (*Spathiphyllum*) and a monstera (*Monstera deliciosa*) for two weeks. The soil moisture threshold was configured at 40% for the peace lily and 30% for the monstera. The system successfully kept soil moisture around or above these levels. The peace lily was automatically watered five times over 14 days, never wilting during the test, whereas a manually cared lily might have dried out. The monstera required three irrigation cycles and maintained steady growth. All scheduled waterings occurred at appropriate times, demonstrating the system's responsiveness. When internet was temporarily disconnected, the ESP32 continued monitoring and watering as needed (confirming offline-first reliability), and cached data synced later. Water usage was efficient – only about 2 liters total across both plants in 14 days – since the pump ran only when necessary. These results indicate that SmartGarden can effectively automate plant care, keeping indoor plants healthy with little oversight.

5 Conclusion and Future Work

SmartGarden provides an effective and economical solution for indoor plant surveillance and irrigation. By combining low-cost IoT hardware with robust software, it ensures plants are watered on time and conditions are monitored continuously. The system performed well in initial tests, improving plant maintenance convenience and consistency. In the future, we plan to extend SmartGarden with additional features such as support for more plant nodes, integration of lighting control for grow lights, and intelligent adjustments based on plant species or growth patterns. We will also conduct longer trials and gather user feedback to further refine the system. Overall, SmartGarden demonstrates that IoT technology – if designed with affordability and offline capability in mind – can make indoor gardening simpler and more sustainable for everyone.

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