ECE445 Project Proposal

Project Leaflink

Team #43

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Introduction

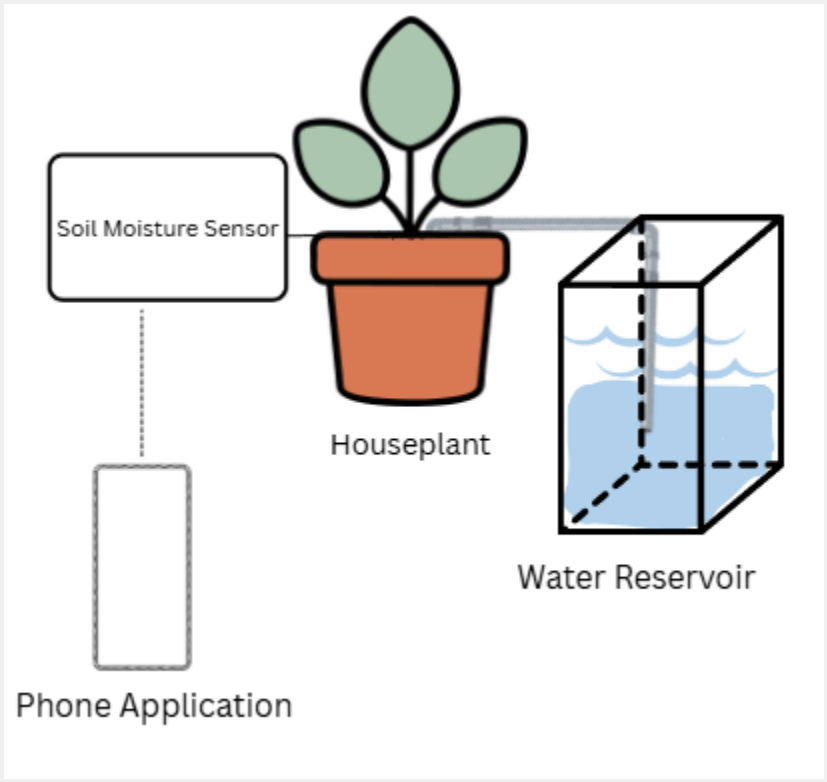
Problem

Indoor plants are a common way to decorate one's living space. They require careful watering and monitoring to make sure they stay alive. However, it is easy to forget to water these plants due to our busy lives or for example, taking a vacation. According to an article published by Medium, around 50% of plant owners kill their plants by forgetting to water them. This problem is addressed by watering systems. However, these systems are simply programmed without sensing important features such as soil moisture and thus run the risk of overwatering.

Solution

Our project provides a standalone device that will automatically sense the moisture level of the soil, and deploy a pump that supplies the plant with just the right amount of water to survive. It will use an onboard soil moisture sensor along with a water pump to supply the plant with water. We will implement a simple light that shows the system's status (normal, watering, or needs attention). It will also include basic safety limits that will prevent the pump from running indefinitely. It will warn the user if the water container is empty or if the device isn't able to pump water properly. The device will store a basic history of when it watered the plant so the user can see that it's working. It will also utilize a companion app that will allow the user to monitor the current soil measure as well as show a log of recent watering. It will allow the user to trigger a manual watering from their phone if needed as well as select the water level.

Visual Aid



High Level Requirements

- The ESP32 on our custom PCB correctly reads soil moisture data and determines when watering is required independently (requiring no supervision)
- Ensure proper functionality of the soil moisture sensor by ensuring moisture readings are accurate (for example if we add water the moisture percentage should get higher)
- The ESP32 reliably controls the relay to turn the water pump on and off based on soil moisture thresholds.
- The water pump operates only through the relay and correctly distributes the required amount of water

- The multiple LEDs correctly indicate the current system states, including idle, watering, and error.
- Pressing the emergency stop button immediately cuts power to the water pump and halts any ongoing operation
- Remote monitoring system displays accurate real-time soil moisture data, logs watering events, and allows manual watering control

Design

Testing Overview:

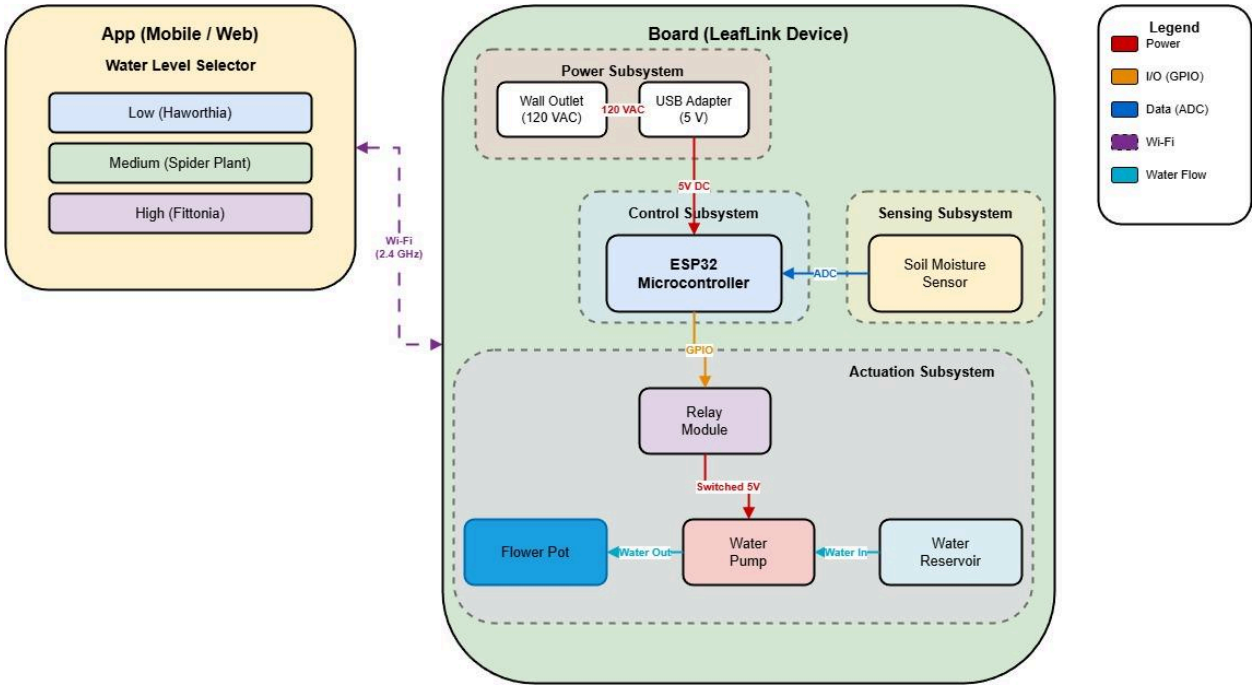
To keep the design simple, the ESP32 should have the following profiles for 3 different plants corresponding to plants that need less, moderate, and a lot of water. To quantify the dosage, we will use the following table to dispense specific amounts of water when necessary to meet the moisture threshold of each plant. We will be using a standard 8in diameter flowerpot for testing. The date in the following table is approximated from the watering requirements of the listed plants found online.

Category	Plant	Moisture Sensor Threshold
Dry	Haworthia	10%
Moderate	Spider plant	25%

Wet	Nerve plant	50%

If time permits, more plants can be added to the table. However, most plants should survive with the 3 different categories of watering (Dry, Moderate, Wet) unattended.

Block Diagram



Subsystem Overview

Power Subsystem

The Power Subsystem converts power from the wall outlet into stable DC voltages needed by LeafLink. The ESP32 microcontroller and relay module are powered by a USB adapter that receives power from an AC wall outlet and outputs 5 V DC. This subsystem powers all of the

other subsystems and connects directly to the Control Subsystem (5 V input), the Actuation Subsystem (switched 5 V to the pump), and indirectly supports sensing and wireless operation by delivering power in a controlled way.

Control Subsystem

The Control and Processing Subsystem is essentially the core logic and decision-making component of LeafLink. The ESP32 microcontroller processes analog soil moisture inputs, executes watering control logic, and handles wireless communication with the app. The interfacing components of this subsystem are the Sensing Subsystem through the ADC, the Actuation Subsystem through GPIO signaling to the relay, the User Interface through status signals, and the Wireless Monitoring Subsystem through its interface.

Sensing Subsystem

The Soil Moisture Sensing Subsystem detects the amount of moisture within the soil with the help of a capacitive soil sensor. The sensor generates an analog voltage signal proportional to the detected soil moisture, which is then detected by the ESP32's ADC. It acts as the primary input source for the system to water the plants and directly connects to the Control Subsystem via an analog signal wire and ground.

Actuation Subsystem

The Water Delivery and Actuation Subsystem is what physically delivers water to the plant when commanded by the control logic. A relay module acts as an electrically isolated switch between the ESP32 and the water pump. When activated via GPIO, the relay supplies power to the pump, which draws water from the reservoir and delivers it to the flower pot. This subsystem interfaces

with the Control Subsystem (GPIO), the Power Subsystem (pump supply), and the physical plant environment.

App Subsystem

The app subsystem allows users to monitor and interact with the LeafLink device remotely. Using the ESP32's built in Wi Fi, the system sends soil moisture data and watering history to our simple mobile/web interface. The app also allows users to manually trigger watering when needed and even select the type of plant to water accordingly. This subsystem connects directly to the control subsystem through the ESP32 and does not affect core watering functionality if it is unavailable.

Subsystem Requirements

Power Subsystem

- Converts wall outlet power into a steady 5 V DC supply for the system.
- Provides enough current to support the ESP32, relay, and pump during normal operation.
- Keeps the 5 V output stable while the pump turns on and off.
- Uses a shared ground so all parts of the system reference the same voltage level.

Control Subsystem

- Reads soil moisture data at least once per second using the ESP32.
- Runs watering decisions automatically without needing user input.
- Sends control signals from the ESP32 GPIO pins to the relay.
- Limits how long the pump runs during each watering cycle to prevent overwatering.
- Continues operating even if the wireless feature is unavailable.

Sensing Subsystem

- Produces an analog signal that the ESP32 can read reliably.
- Gives consistent readings when soil conditions stay the same.
- Changes output clearly as soil becomes wetter or drier.
- Operates safely from the system's 3.3 V supply.

Actuation Subsystem

- Relay responds correctly to control signals from the ESP32.
- Relay keeps the ESP32 electrically separated from the pump power circuit.
- Pump turns on only when the relay is activated.
- Pump delivers enough water to noticeably increase soil moisture.
- Emergency stop immediately shuts off pump power when pressed.

App Subsystem

- Displays accurate and real time soil moisture readings from the ESP32.
- Must have a history page where it shows recent watering events statistics.
- Allows the user to manually trigger watering through the interface.
- Sends user commands to the ESP32 through WiFi and can specify the specific type of plant being watered to adjust watering accordingly.
- Does not interfere with autonomous watering if the connection is lost.

Tolerance Analysis

Power Subsystem

A main risk in the power subsystem is that the pump draws a burst of current when it first turns on. This can briefly pull down the 5 V supply and cause the ESP32 to reset. To prevent this, we will choose a power adapter with enough current headroom and include capacitors near the ESP32 and relay to smooth short voltage dips. This keeps the system stable even when the pump starts suddenly.

Control Subsystem

The control subsystem is sensitive to small fluctuations in sensor readings near the watering threshold. Noise in the sensor signal could cause the system to rapidly switch the pump on and off. To reduce this risk, the firmware will average multiple readings and use slightly different thresholds for turning watering on and off. This helps the system make stable decisions even when readings vary slightly.

Sensing Subsystem

Soil moisture sensors can behave differently depending on soil type, placement, and packing. This means the same level of moisture may not always produce the same voltage reading. To handle this, the system will rely on relative calibration by observing dry and wet conditions rather than using a fixed voltage value. By averaging readings and adjusting thresholds based on actual measurements, the sensing system remains reliable despite some natural noise.

Actuation Subsystem

The pump may not always deliver the same amount of water because flow rate depends on tubing length, reservoir height, and pump variation. Instead of assuming a fixed output, the system will water in short bursts and re-check soil moisture after each burst. This closed-loop approach ensures that watering is based on actual soil response rather than assumed pump performance, reducing the chance of overwatering.

App Subsystem

The main risk in the app subsystem is bad WiFi connectivity or unexpected signal drops or delays that could prevent real time updates or manual watering commands from reaching the device. As the app is supplementary but not required to operate the Leaflink, we have designed this system so that all critical watering decisions are made locally by the ESP32. So essentially the app is treated as an optional monitoring and control tool rather than a required component. This will help us ensure that the device continues operating normally even if the wireless connection is unstable or unavailable.

Ethics and Safety

This project involves the design of an automated plant watering system using an ESP32, soil moisture sensor, water pump, and companion mobile application. While the system is intended for benign household use, several ethical considerations arise during both development and deployment.

Leaflink aligns with the IEEE code of ethics by respecting the importance of public safety through safety measures. We will provide an emergency stop button to prevent damage to the plant, water waste, and etc. Furthermore, our system will be honest by providing reliable data according to its sensors. This is in accordance with the IEEE code of ethics that requires honesty and transparency. The collected data will be stored securely and not shared with anyone but the consumer. All electrical components will follow industry standards in order to ensure public safety. There will be no exposed wires and they will all be properly grounded.

During development, we will also make sure to unplug the system every time we need to work on it to avoid contact with direct power. We will accept criticisms from peers as well as TA and others that oversee our work. In accordance with campus policy and the IEEE code of ethics, we will be respectful of each other and everyone we interact with.

Works Consulted

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