UCF Senior Design 1 Divide and Conquer Document
BioSensePot

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University of Central Florida
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Initial Project Document and Group Identification
Divide and Conquer

Group 9 CREOL

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Introduction / Narrative:

Motivation:

We depend on plants for oxygen, food, and medicinal resources in our environment. There are, however, some plants that aren't safe, some may be poisonous to humans and animals, while others produce toxic fruits despite appearing harmless. With this senior design project, we aim to develop a laser-based optical system that identifies a plant's color and determines whether it is poisonous. Botanists, gardeners, and farmers will be able to distinguish between safe and harmful plants using this technology. Moreover, understanding the interactions among different plants is important because some can inhibit another's growth by competing with it or by releasing toxic chemicals.

Our project aims to understand how environmental factors such as temperature, moisture levels, and climate affect plant color and growth in addition to identifying toxicity. Monitoring these variables will ensure optimal plant health and productivity conditions, resulting in better farming practices. Furthermore, knowing the difference between invasive and native plants' growth rates can help prevent the spread of invasive species. Using optical laser technology, our project bridges the gap between science and agriculture, providing an effective and efficient tool to help gardeners and farmers make informed decisions about plant health.

Project Background

Traditional methods of identifying plant characteristics, such as toxicity and health, relied on chemical testing or expert knowledge. For gardeners and farmers operating on a large scale, these methods are costly, time consuming, and impractical. The goal of our project is to develop a fast and reliable alternative to traditional methods of analyzing leaf color and detecting potential toxicity using optical laser technology.

The NIH Library identifies two categories of plant disease detection methods: direct and indirect. A direct method of identifying pathogens, including bacteria, fungi, and viruses, involves molecular and serological analysis. A variety of indirect methods can be used to assess plant health by analyzing changes in morphology, temperature variations, transpiration rates, and volatile organic compounds released by infected plants. Through the use of laser-based analysis as an indirect, noninvasive method of plant identification, we aim to contribute to this field. Our aim is to make gardening easier for both new and experienced gardeners by leveraging this technology to better understand plant life mechanisms, use safer cultivation practices, and optimize growth conditions based on environmental factors.

Vision and Impact

Basic Goals:

1. Optical Laser Detection of toxic plants: Develop a reliable optical method for determining plant toxicity using laser sensors to detect poisonous plants efficiently by analyzing leaf coloration.
2. Assess plant health by measuring leaf color – Detecting discolorations, which indicate disease, stress, or nutritional deficiencies, using laser analysis techniques.
3. Monitors for ambient temperature - Detection of ambient room temperature for the purpose of further informing the user on the plant's environment
4. Monitors for incoming light intensity - Detection of incoming light intensity (from ambient and grow lamps), for the purpose of further informing the user on the plant's environment
5. Sustainable power management – Develop a sustainable power management system for the laser detection and monitoring setup, ensuring energy efficiency and minimal environmental impact.
6. Solar panel power: Providing clean energy and secondary power supplied to the system

Advanced Goals:

7. Automated watering and lighting system – Integrate light and moisture sensors with an automated system to adjust lighting and watering for plant health optimization.
8. Plant Identification – Develop a comprehensive plant identification system that accurately determines plants using laser-based optical technology, benefiting farmers, gardeners, and researchers.
9. An online monitoring and control system – Develop a mobile or web-based interface to allow users to remotely access plant health data and receive alerts for potential plant issues.
10. Soil moisture monitoring - Develop an optical system below the soil that provides an accurate reading of soil moisture, for the purposes of determining whether or not the plant needs to be watered again.

Stretch goals:

11. Growth Prediction – Develop a predictive algorithm based on historical data and weather conditions to determine the optimal timing of watering and lighting.
12. An AI-powered assistant for monitoring plant health – Establish an AI-powered assistant that provides insights, recommendations, and real-time data on plant health to users.

We envision transforming plant health monitoring and toxicity detection through the use of smart automation and laser-based optical technology. Thus, with the laser monitoring of leaf color, a safe and reliable system is targeted for development, which detects toxic plants and plant toxicity. The system will also enable real time feedback of environmental conditions while detecting toxicity through the study of leaf temperature, discoloration, and light intensity. In a bid to conserve the environment, the systems will incorporate the solar panel into its power management.

Moisture and light sensors will be used to enhance automated watering and lighting systems for optimal plant growth. Furthermore, an identification system for plants using laser-based spectroscopy will accurately classify different plant species. In addition, remote access for users to see real-time data, whether for alerts or insights on their plant health, is enabled under the online monitoring and control system.

A further enhancement to the system will include predictive monitoring of plant growth through historical data analysis as well as environmental factors for AI-based watering and lighting control. It will also incorporate an AI-based assistant for real time customized recommendations on plant care. By converging on cutting-edge laser technology, automation, and artificial intelligence, this project offers a disruptive, sustainable, and scalable solution for plant monitoring to farmers, gardeners, researchers, and the general agricultural community.

Implementation Strategy

Basic Objectives:

1. Develop an Optical Laser Detector for Plant Identification
    a. Assess leaf color and detect toxicity with laser-based imaging. The plant's spectral signature can be identified by using different wavelengths of light. Check laser readings with data on plant toxicity to validate results.
2. Determine Plant Toxicity Using Optical Analysis
    a. The identification of poisonous and non-poisonous plants must be based on a reliable method. Detection accuracy can be improved by conducting laboratory tests with a variety of plant species. Utilize the spectral characteristics of common poisonous plants to create a toxicity database.
3. Assess Plant Health by Monitoring Leaf Coloration
    a. Analyze discolorations associated with diseases, stress, or nutrient deficiencies using laser reflections and absorptions.
4. Monitor Ambient Temperature and Incoming Light Intensity
    a. Temperature can be measured using sensors. Analyze how these conditions impact the environment it's in.
    b. Analyze the measurement of the light intensity and compare the light intensity as the plant grows.
5. Implement sustainable power management
    a. Energy efficiency can be achieved by integrating a solar-powered system. Design circuits that consume as little energy as possible when detecting lasers. To ensure continuous operation, develop a battery storage system.
6. Solar panel power
    a. Utilize a solar panel as a secondary source of power when the battery is finished.

Advanced Objectives:

7. Automated Water and lighting systems
    a. Install moisture sensors to trigger an irrigation system when the soil is dry. Integrate light sensors to adjust LED grow lights based on ambient lighting levels. Use real-time data processing to enhance automatic adjustments.
8. Plant Identification Using Laser
    a. Use spectral data to train machine learning models to recognize plant species. A comparison of laser-based plant identification and traditional flower classification methods is provided. Through iterative testing and algorithm refinement, improve detection accuracy.
9. Develop an Online Monitoring and Control System
    a. Provide users with real-time access to plant health data via a mobile or web-based platform. Ensure that critical plant conditions are alerted and notified.
10. Soil monitor moisture
    a. Installed under the soil to measure the moisture content of the plant in order to prevent damage to the plant.

Stretch Objectives:

11. Develop AI-Driven Growth Prediction Models
    a. Data from historical plant health and environmental conditions can be used to train predictive algorithms. Using artificial intelligence, recommend the best watering and lighting schedule for your plants. Improve predictions continuously with adaptive learning.
    b.
12. Implement an AI-Powered Plant Health Assistant
    a. Create a chatbot based on collected data that provides real-time insights. Implement AI-driven plant care recommendations. Use a mobile app to facilitate interactive communication.

The focus is on creating a cutting edge system that is capable of plant identification and health monitoring. In this proposal, laser examination, smart automation, and AI will be integrated into an example of a safe, efficient, and friendly tool for farmers, gardeners, and researchers alike.

Leaf coloration will indicate diseases, and with laser based optical analysis, we intend to identify and evaluate plant toxicity and health. Environmental data in real time, such as temperature, light, and moisture, will be integrated. Solar panels are therefore considered to further conserve energy and extend the lifetime of all systems.

The system will have water and light plants automated according to environmental changes. An online monitoring platform will allow the user to monitor their plant health data and receive notifications. An AI-enhanced smart assistant will provide useful insights and intelligent recommendations for plant care in order to advance the plant monitoring field.

A scalable energy-efficient intelligent solution for plant management. By combining laser technology, artificial intelligence, and AI-based monitoring, our solution is bridging the gap between technology and agriculture.

Key features and functionalities:

In addition to simplifying plant care, these features and functionalities also utilize advanced technology to optimize growing conditions and improve plant health.

Water Level Monitoring: Keeping track of the pot's water level so it doesn't overflow. Maintaining the correct water level is crucial for plant health, as both overwatering and underwatering can harm roots. An optimal water level ensures plants receive the right moisture, promoting healthy growth and preventing root rot. By monitoring water levels, the smart plant pot creates an ideal environment for plants to thrive.

Temperature monitoring: Tracks the temperature around the plant for optimal growing conditions. The extreme fluctuations in temperature can cause plants to stunt their growth or even die. Plants can become dehydrated, and the soil can dry out due to high temperatures that cause excessive evaporation. In contrast, low temperatures can cause long-term plant damage by slowing down plant metabolism and freezing the roots.

Light monitoring: Makes sure the plant receives sufficient light for photosynthesis by measuring light intensity. Light monitoring ensures that the plant gets the right amount of light necessary for healthy growth and development. By adjusting the plant's exposure to light based on monitored data, it can optimize photosynthesis, leading to more healthy and vibrant plants. Additionally, light monitoring helps prevent leaf burn by keeping light levels balanced.

Automated Watering: Watering the plant according to soil moisture.

Automated Lighting: Creates optimal lighting conditions by adjusting grow lights based on light intensity readings.

Data Collection: Records water levels, soil moisture, temperature, and light continuously.

Responsive Control Mechanisms: Respond to environmental changes in real time, ensuring optimal plant growth.

Touchscreen and Mobile App: Provides visual feedback on soil moisture, temperature, and lighting conditions. Alerts the user when conditions are not optimal, allowing them to make adjustments quickly. Provides detailed reports on plant growth and conditions.

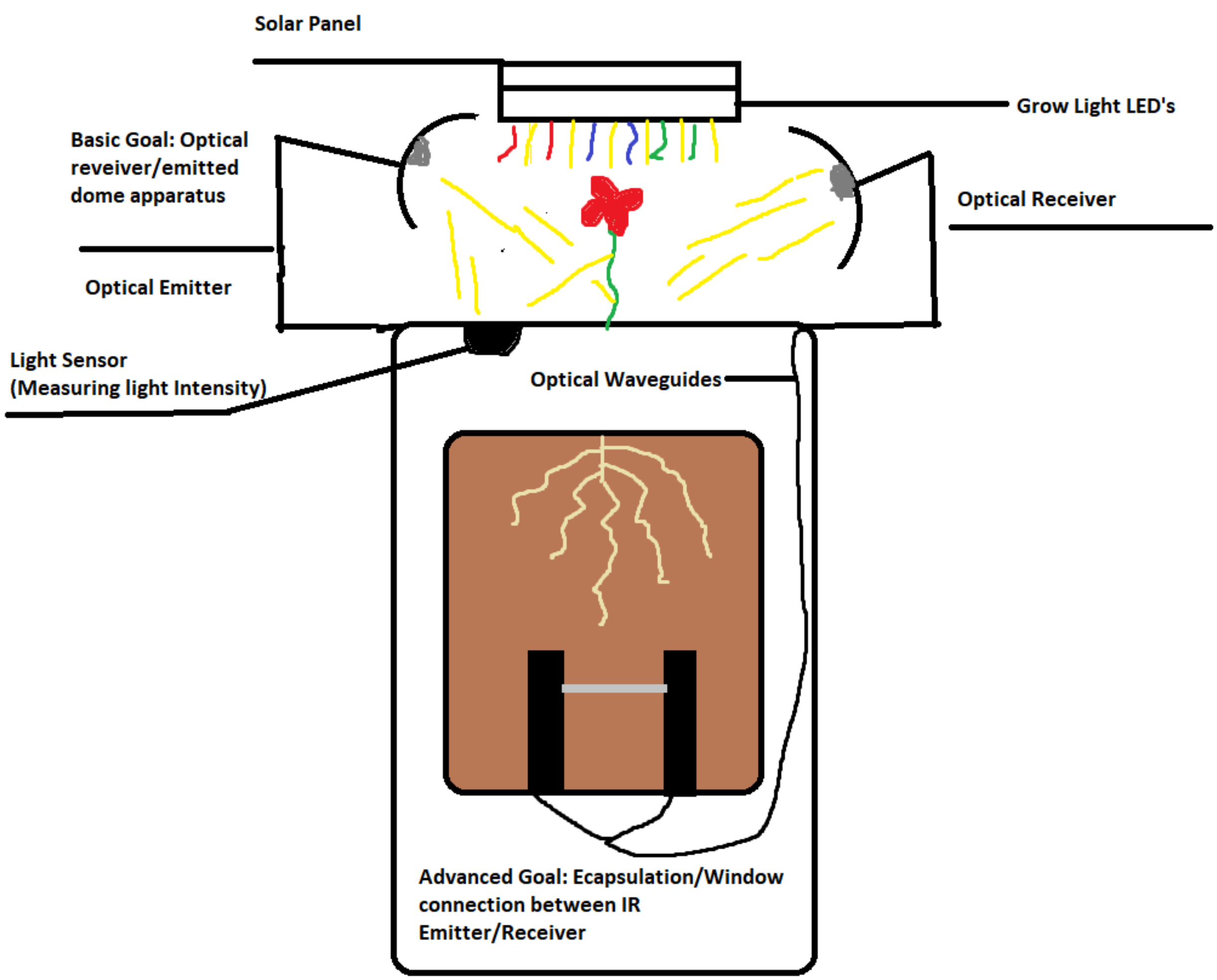
Existing Products or Similar Ideas:

In order to develop this project idea, we observed several "smart pot plant" systems on YouTube, particularly those by creator Tommy Feng. Through his videos, Tommy shows how monitoring water levels, soil moisture, temperature, and light can dramatically improve plant growth. His system incorporates sensors and simple automation, demonstrating how even small, indoor setups can yield impressive results with the right controls. It was evident when we saw these systems in action how important real-time data collection is, as well as responsive control mechanisms, both of which directly influence the design of an automated smart flower house.

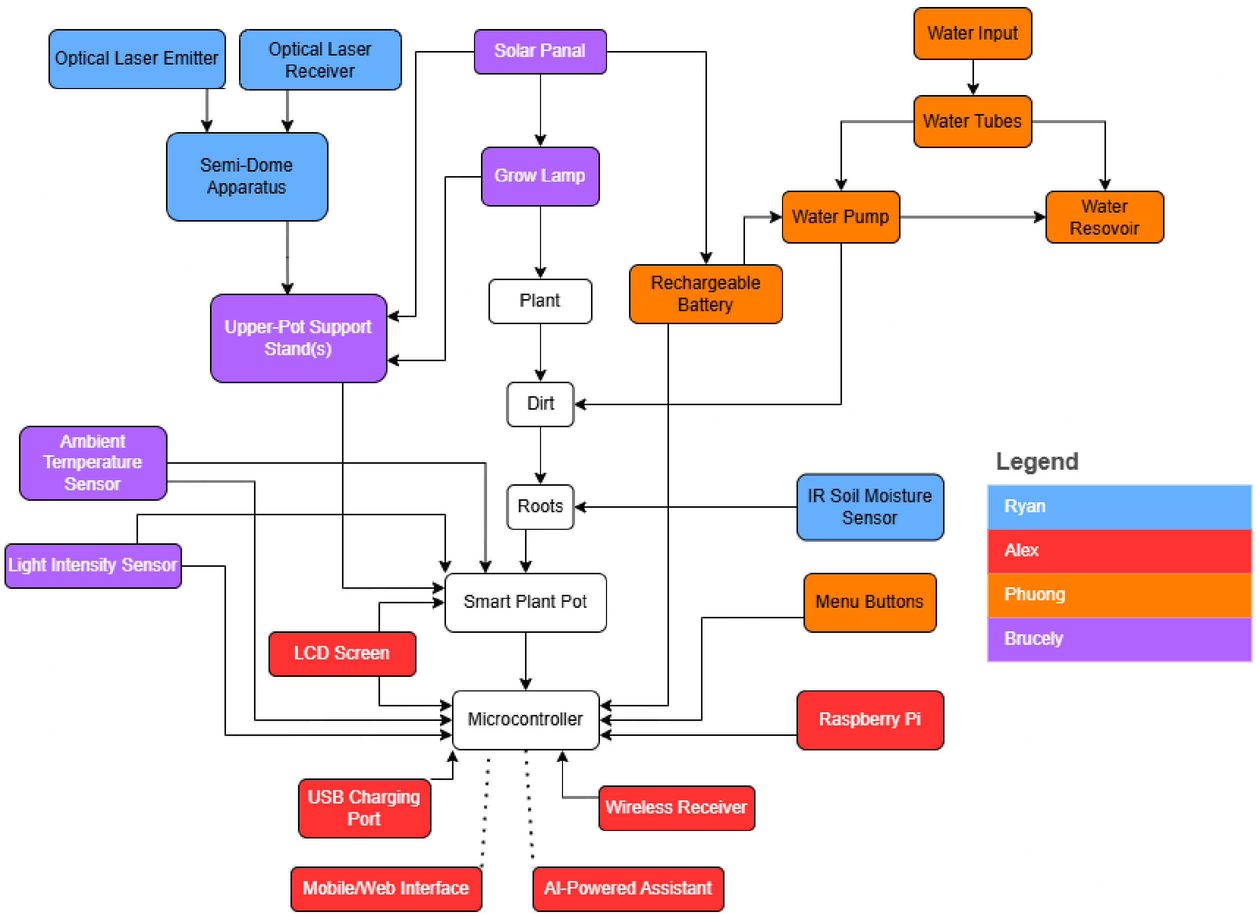
In addition to videos exploring light transmission, another source of inspiration was YouTube. We were intrigued to learn how optical communication could be applied to plant care after witnessing the practical implementation of optical communication. Although many people use light in networking scenarios for high-speed data transmission, these videos prompted me to consider whether elements, like grow lights, could also be adapted for other uses. Despite not directly focusing on photonic data transmission techniques, our project borrows from the concept of utilizing light to bolster plant health. It creates a system that incorporates sensing, feedback, and illumination interconnectedly.

In these videos, the smart plant projects illustrate environmental control, while data transmission demonstrations demonstrate creative light use. The envisioned system is meant to go beyond simple watering timers and passive lighting. In contrast, it emphasizes monitoring and capturing data, as well as potentially integrating sophisticated optics. The references highlighted here demonstrate how modern technology can be used to cultivate healthier, more robust plants by combining innovations in different fields.

Optical Design:

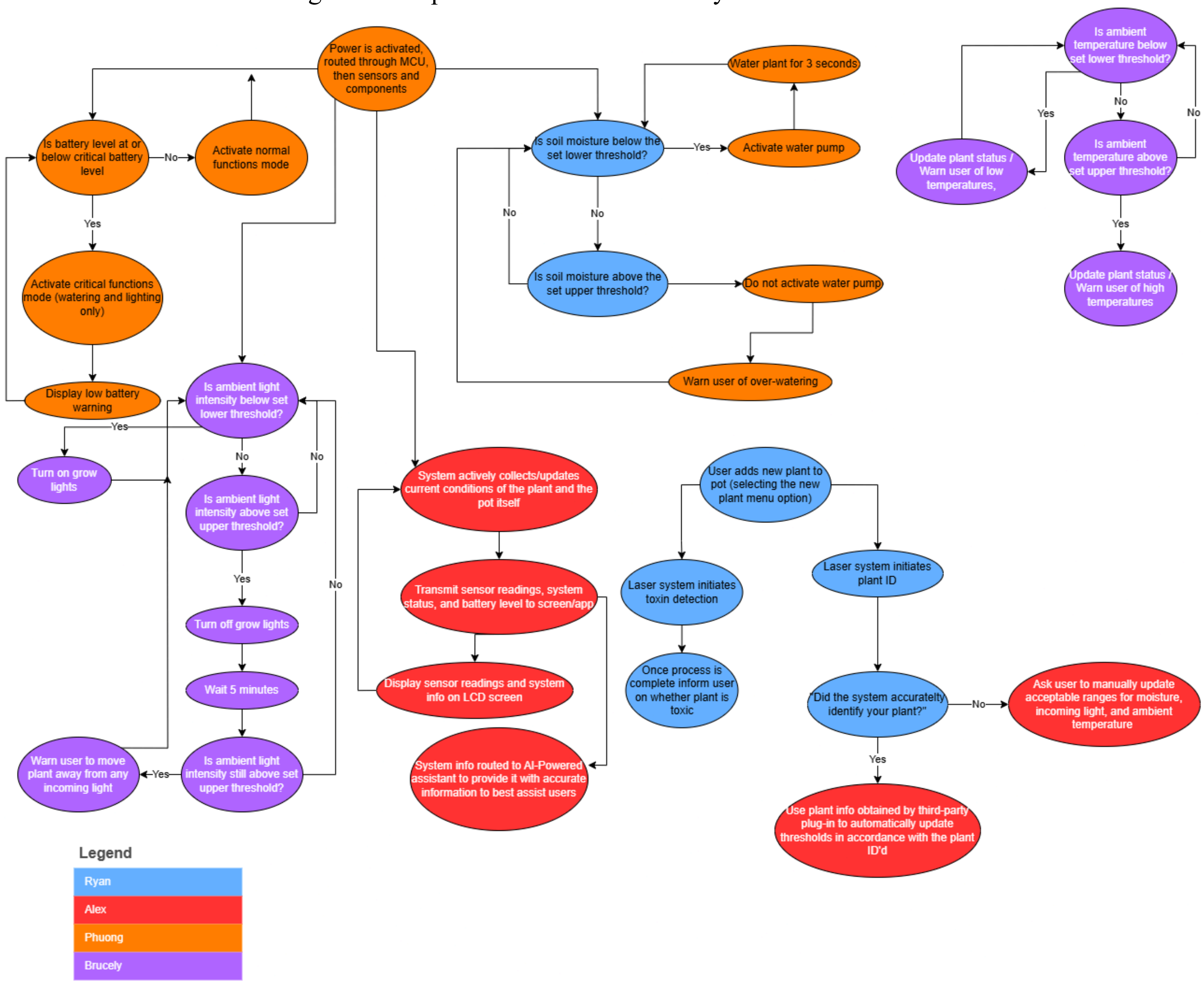


Block Diagram



Flow Chart

This is the flowchart detailing the basic processes and functionality of the BioSensePot:



Requirement Specification:

Product	Quantitative Measures	Engineering Requirement	Market Requirement
Plant optical laser detector	The ability to detect plant coloring variations with precise accuracy	High precision laser technology for accurate detection. Durability for indoor use	1,9
Plant Toxicity Detection Accuracy	≥90% accuracy in identifying poisonous plants versus non-poisonous	High sensitivity sensors for detecting a wide range of toxins. Integration with data processing software for accurate results.	2,5
Sustainable power management	Stores power that is usable for at least or more than hour	A solar power system with an efficient conversion of energy and a high power capacity	5,10
Monitors Light intensity	Accuracy should be plus or minus 10% deviated	A continuous measurement of ambient light.	4,7
Automated Watering System	Upon detection of the moisture threshold, water is delivered within five seconds or less	A low voltage pump or valve is required to deliver water.	3,8
Soil Moisture System	Accuracy of the moisture reading must be within the range of plus or minus 10%	Detection of moisture using a microcontroller.	2,7

Marketing Requirements

1. It should be easy to transport and suitable for indoor and outdoor use.
2. Plant health of soil moisture, temperature, and humidity should be provided continuously and reliably by the system.

3. Extended periods without user intervention should be possible.
4. When there is little natural light, solar lighting should be able to support plant growth.
5. Solar power is one of the most environmentally friendly options, and it should be energy-efficient.
6. Users must be able to easily use the user interface.
7. Monitoring and remote management must be enabled by data logging and potential artificial intelligence connectivity.
8. Installations must be safe to operate, free of leaks and electrical hazards.
9. The product must be designed in a size and weight range that is manageable by average consumers.
10. System cost should be low enough to allow consumers to buy it but still efficient.

Budget and Financing

Item	Estimated Price	Quantity	Details
Microcontroller	$29	1	A low-power microcontroller like Arduino Uno or ESP32 to control sensors and actuators.
Temperature sensor	$6	1	A temperature and humidity sensor to collect data of temperature surrounding the plant pot.

Relay Module	$5	1	A relay module to control high-power devices like water pumps and lights.
Water Pump	$15	1	A low-voltage DC water pump to control watering. Suitable for small to medium-sized pots.
LED Grow Lights	$25	1	Energy-efficient grow lights (adjustable intensity) to support plant growth.
Photo Sensor/Light Sensor	$3	1	A simple light sensor to detect ambient light levels and trigger lighting.
Solar Panel	$30	1	A solar panel to charge the system's battery and power the system (choose according to expected load).
Lithium Battery	$20	1	Rechargeable battery to store solar energy and provide power to the system during low sunlight periods.
Battery Management System (BMS)	$10	1	A BMS to safely manage charging and discharging of the lithium battery.
Pump Valve (for irrigation)	$10	1	A valve to control the flow of water through the irrigation pipe.
LCD Display (16x2 or 20x4)	$10	1	A simple LCD screen to display sensor data (e.g., moisture, temperature, humidity).
Resistor, wires, connectors	$10	1	Miscellaneous electronics components (resistors, jumper wires, etc.) for connections.
Enclosure Box (waterproof)	$15	1	Protective enclosure for the electronics to ensure safety and durability in both indoor/outdoor settings.
Connectors (for sensor wiring)	$5	1	For connecting sensors, relays, and pumps to the microcontroller.
Miscellaneous (mounting, etc.)	$10	1	Mounting hardware, screws, and adhesives to fix sensors, components, and wiring.
Miscellaneous Cost for Safety and Debug	$20	1	Cost for debugging, safety, and testing components, including tools.

LD Emitter	$50	1	Above surface Laser Diode emitter for exciting the observed leaf/plant part (Plant ID/Toxin detection)
LD Receiver	$50	1	Above surface laser diode receiver for receiving the signal produced by plant system excitation by the emitter (Plant ID/Toxin detection)
IR Emitter	$10	1	Underground infrared emitter for optically exciting soil (Moisture detection system)
IR Receiver	$10	1	Underground infrared receiver for receiving signal produced by excitation of dirt system (Moisture detection system)

House of Quality Parts:

Engineering Marketing Trade Off Matrix

Table 3.5

	Laser Based	Compacted and lightweight	Wireless Connectivity	Automated Water	Automated Light	Toxic Detection	Cost Effective
Measure leaf color	↑↑	↑	↑			↑↑	↓
Automated Plant Care	↑	↑	↑↑	↑↑	↑↑	↑	↓
Capacity Power	↑	↓↓	↑	↑	↑	↑	↓↓
App with Ai interface	↑		↑↑	↑	↑	↑	↓
Temperature Sensor			↑	↑	↑		↓
Scalability		↑					↓
Cost Effective	↓	↓	↓	↓	↓	↓↓	

Using the Engineering Trade Off Matrix in Table 3.5, we show the relationships among different system attributes that are positive or negative. To detect plant health and toxicity, the laser based detection system depends heavily on precision spectral analysis of leaf coloration. In the same way, the Automated Plant Care system improves efficiency and ease of maintenance in plant growth optimization by improving multiple features. There are mixed correlations between Automaticity and Connectivity and Capacity Power, suggesting that while power capacity supports automation and connectivity, it compromises portability, cost effectiveness, and size. A strong positive correlation exists between AI driven application interfaces and cost effectiveness, indicating that advanced AI features might increase system complexity and cost.

Table 3.6

	Laser Based	Compacted and lightweight	Wireless Connectivity	Automated Water	Automated Light	Toxic Detection	Cost Effective
Measure leaf color		↑					↓
Automated Plant Care	↑	↑	↑	↑	↑		↓
Capacity Power	↑		↑	↑	↑		↓
App with Ai interface			↑	↑	↑		↓
Temperature Sensor					↑		↓
Scalability						↑	↓
Cost Effective							

Milestones / Schedule:

Senior Design 1- Spring 2025			
Task	Time period	Dates	Responsibility
Project Selection	2 Weeks	01/10/2025	All
D&C Documentation	1 Weeks	1/24/2025	All
D&C Meeting With Advisors	30 Minutes	01/28/2025	All
System Design Documentation	1 week	01/30/2025	All
Circuit and Sensor Assembly	2 weeks	02/15/2025	Phuong, Brucely
Light-Seeking Algorithm	2 weeks	02/25/2025	Alex, Ryan

Implementation			
Watering and Environmental Monitoring	2 weeks	03/05/2025	Phuong, Brucely
Solar and Power Management System	2 weeks	03/05/2025	Alex, Ryan
Prototype Integration	1 weeks	03/28/2025	All
Testing and Performance Analysis	1.5 week	04/04/2025	All
Final Report and Presentation	7-8 week	02/25/2025- 04/22/2025	All

Appendice

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