Boston University
Electrical & Computer Engineering

EC 464 Senior Design Project

Second Prototype Testing Plan

by

Team 26

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Required Materials

Hardware:

- Raspberry Pi 5
- 24V DC Power Supply
- 24V to 12V DC-DC Converter
- 12V to 5V DC-USB-C Output Converter
- Raspberry NoIR Camera Module
- 12V Peristaltic Water Pump
- 12V Solenoid Valves (2)
- Grow Light LED Strips (2)
- Soil Moisture Sensors (2)
- Temperature Sensor
- Humidity Sensor
- Air Quality Sensor
- 3 SRD Relays (Used to boost MOSFET current—one for the water pump, one for each LED strip)

Software:

- Python 3 Scripts (Raspberry Pi GPIO control, sensor handling, automation logic)
- Capturing Photos & Object Recognition (OpenCV, TensorFlow for plant analysis)
- React Native Expo (Mobile/Web UI for monitoring and control)
- Node.js Web Server (Data visualization and API communication)
- Adafruit Sensor Libraries (for data collection from environmental sensors)
- Firebase (Cloud-based data storage and real-time updates for system communication)

Modes of Operation:

1. **Manual Mode:** User manually controls watering and lighting via the web app.
2. **Schedule Mode:** User sets predefined schedules for watering and lighting cycles.

Set Up

The system consists of the following components:

- **Raspberry Pi 5:** Manages all sensor readings (soil moisture, temperature, humidity, and air quality), controls the water pump and grow lights via GPIO and SRD relays, and processes infrared images for plant health monitoring.

- **Power Supply:** Uses a 24V DC power supply with two DC-DC converters (12V for the water pump and solenoids, 5V for the Raspberry Pi).
- **Web App:** Displays real-time sensor data, images captured by the camera, and AI-based plant health assessments.

Note: The water level sensor is not used in this prototype due to wire length limitations and the need for it to float.

Pre-testing Setup Procedure

1. Connect all sensors (soil moisture, temperature, humidity, air quality) to the Raspberry Pi and verify communication.
2. Ensure the Raspberry Pi is connected to the NoIR Camera and can capture infrared images using Python.
3. Verify optimal water levels in storage manually.
4. Set up the DC power supply to provide 12V power for the water circuit and 5V for the Raspberry Pi and grow lights.
5. Ensure proper relay control for the water pump and LED strips via the SRD relays.
6. Upload and run the control code on the Raspberry Pi for automation and monitoring.
7. Run a test script to ensure image capture and AI-based plant monitoring functions correctly.

Workflow Testing

1. **Grow Light Activation** → Raspberry Pi triggers grow lights via SRD relays based on the selected mode (Manual, or Schedule).
2. **Watering System**
    - If soil moisture sensor detects dry soil → Raspberry Pi activates the water pump.
    - The system alerts the user if water levels are low (manually checked in this prototype).
3. **Camera & AI Processing**
    - Camera captures plant images in IR → Raspberry Pi processes plant health using AI.
    - Web app displays sensor data, IR plant images, and AI-based assessments.

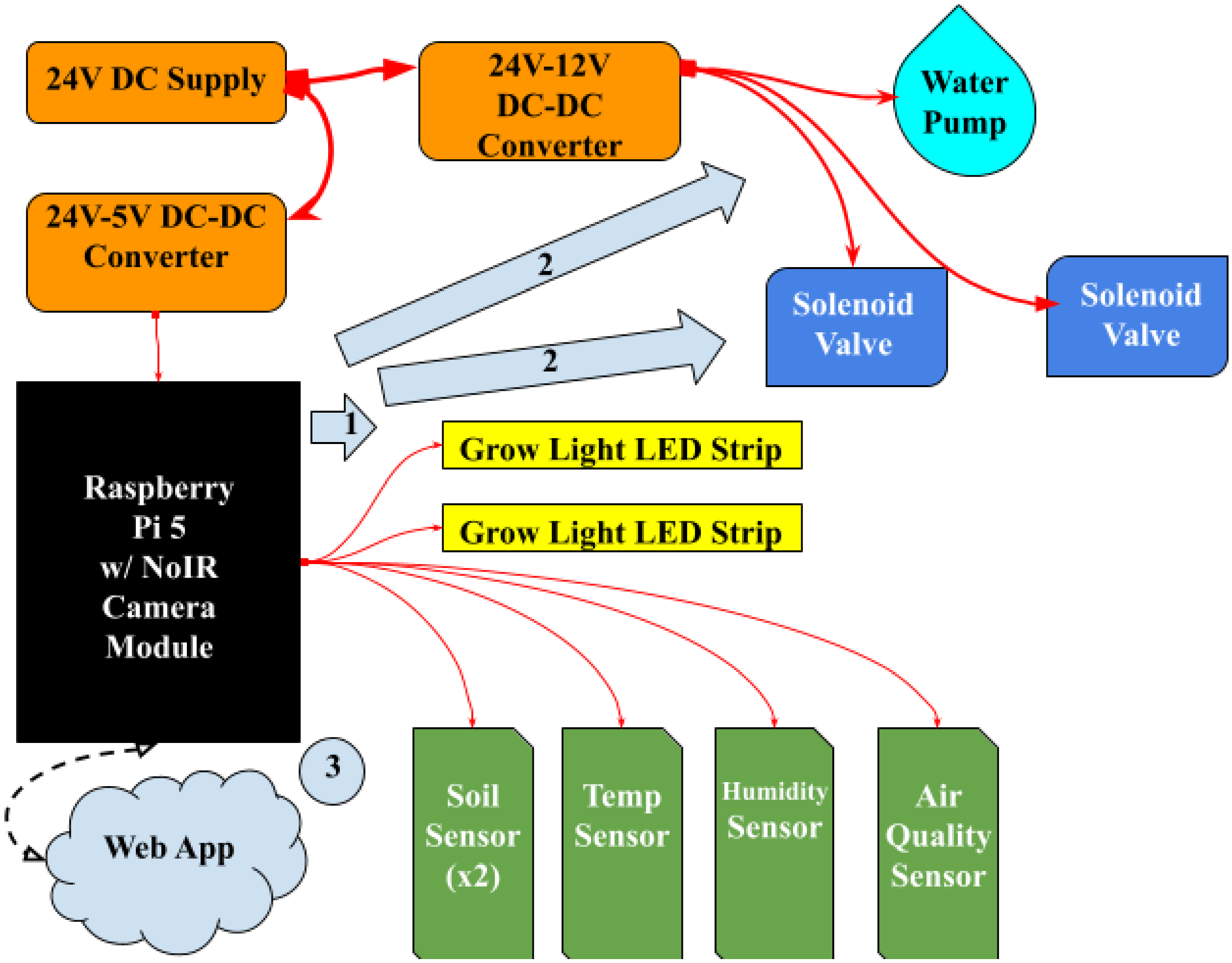

Figure 1: Illustration of Setup and Process Flow

Testing Procedure

Grow Light Test
- Verify that the Raspberry Pi triggers the grow lights via SRD relays according to the mode settings.

Water Pump & Soil Moisture Test
- Measure soil moisture levels using sensors.
- Ensure the water pump activates and stops at the desired moisture level.
- Validate the ON/OFF command functionality for the pump.

Camera & AI Image Processing Test
- Capture infrared images of the plants (lettuce, spinach, tomato) using the NoIR camera.
- Process captured images with AI to assess plant health and growth.
- Display real-time plant status on the web app.

Sensor Data Integration Test

- Collect real-time data from all sensors (soil moisture, temperature, humidity, air quality).
- Verify that the Raspberry Pi sends this data to Firebase and the web app.
- Check the accuracy and stability of displayed data.

Measurable Criteria

Test Case	Expected Outcome	Pass/Fail
Grow Light Control A. *Scheduled mode* *B. Manual mode*	Lights turn on/off as scheduled or in manual mode	
Water Pump Activation *A. Scheduled mode* *B. Manual mode*	Pump activates at low moisture and stops when sufficient	
Image Capture	Successful infrared image capture	
AI Plant Assessment	Accurate AI evaluation of plant health	
Sensor Data Display	Real-time, accurate data on web app and Firebase	
Power Consumption	System operates efficiently	

Future Plans & Notes

- **Heater Implementation:** The heater will be added in the final product but is not used in this prototype.
- **PCB Integration:** The second prototype does not use a custom PCB, but a PCB will be implemented in the final version for better efficiency and reliability.
- **Historical Data Storage:** The web app may store historical plant images and sensor data, but currently, only recent data is retained due to storage constraints.
- **Improved GUI & AI Integration:**
  - The app will have a more intuitive interface.
  - AI will provide recommendations for plant care based on image analysis.
  - Sensor data visualization will be enhanced for better user experience.

Conclusion

The Simple Sprouts project integrates automated plant care with real-time monitoring, using Raspberry Pi-controlled sensors, relays, and AI-powered plant analysis. The system successfully incorporates manual and scheduled modes, providing flexibility based on plant needs. The cloud integration with Firebase allows seamless communication between components, ensuring efficient control and data storage.

The hardware implementation balances efficient power distribution, using a 24V DC supply stepped down to 12V and 5V for various components. The NoIR camera and AI model enhance the system by enabling plant health monitoring through infrared imaging, providing valuable insights into chlorophyll content and overall plant well-being.

While this prototype has validated key functionalities, future iterations will include a heater, PCB integration, and improved AI recommendations for plant care. With real-time data processing, image analysis, and an intuitive web-based control system, Simple Sprouts is a scalable solution for automated indoor gardening, offering a blend of technology and agriculture for sustainable growth.