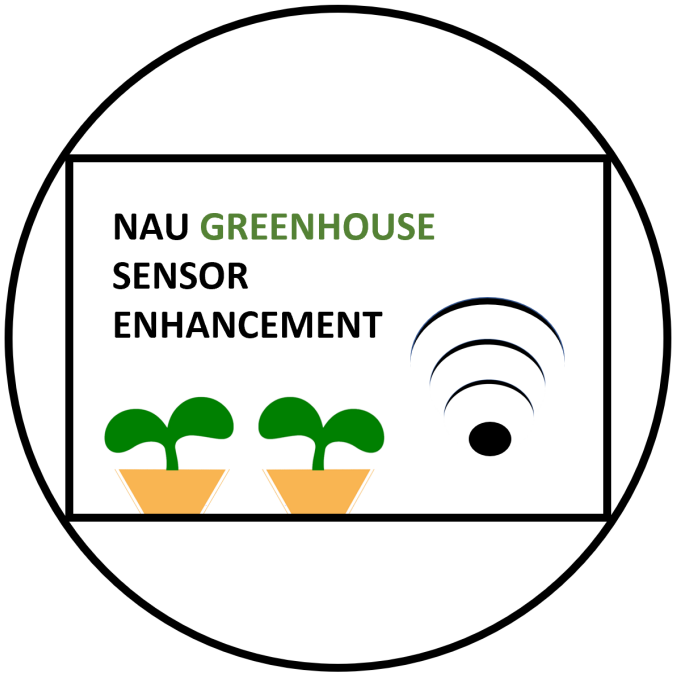
2021-2022 Capstone in Electrical Engineering: NAU Teaching Greenhouse



SYSTEM REQUIREMENTS

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Introduction

This document serves to define the system requirements agreed upon by client Dr. Tina Ayers and the capstone team. Requirements designated as "Threshold" requirements are required for successful completion of the project. Those requirements designated as "Objective" requirements are desired but not strictly required.

These requirements are subject to change as further agreed by the client and team.

Requirements

1. **Environmental Monitoring Requirements**
    - **1.1. Temperature and Humidity Monitoring (Threshold)**
        - 1.1.1. The north house shall be equipped with at least two temperature and humidity sensor modules.
        - 1.1.2. The south house shall be equipped with at least eight temperature and humidity sensor modules.
        - 1.1.3. Temperature sensors shall be accurate to +/- 2℉ or better.
        - 1.1.4. Humidity sensors shall be accurate to +/- 5% or better.
        - 1.1.5. All sensors shall operate properly in temperatures from 40 to 120 ℉.
        - 1.1.6. All sensors shall operate properly from 0 to 100% humidity.
    - **1.2. Soil Moisture Content Sensors (Objective)**
        - 1.2.1. The greenhouse shall have at least 3 mobile sensors that are available to monitor the moisture content of the soil in any container.
        - 1.2.2. Soil moisture content readings shall be accurate to +/- 5% or better.
        - 1.2.3. Soil moisture sensors shall comply with the operating conditions specified for temperature and humidity sensors.

2. **Logging Requirements**
    - **2.1. Temperature and Humidity Logging (Threshold)**
        - 2.1.1. Temperature and humidity data shall be retrieved from sensors and stored at intervals of 15 minutes or less.
        - 2.1.2. Environmental logs shall include, at a minimum, the temperature and humidity reported by each sensor and the time and date of the reading.
        - 2.1.3. The system shall have adequate storage to retain logged data for at least two years.

3. Presentation Requirements

3.1. Current Conditions Dashboard - Numerical (Threshold)

3.1.1. A web interface shall numerically show temperatures and humidities from the latest reading.

3.1.2. The web interface shall be accessible from off campus without use of the VPN. (**Objective requirement**, subject to NAU ITS approval)

3.2. Past Conditions - Graphical (Threshold)

3.2.1. The web interface shall be able to show graphs of recent temperature and humidity data, either individually per sensor, or using an average for each section of the greenhouse.

3.2.2. The time range of the graphs shall be user-selectable (allow the user to view data from the last 24 hours, 7 days, month, etc).

3.3. Data Export (Objective)

3.3.1. The system shall provide a method for users to retrieve a CSV file containing all logged data, without requiring user knowledge of linux tools such as scp or sftp.

4. Alerting Requirements

4.1. Unsafe Conditions Alert (Threshold)

4.1.1. A smartphone alert will notify Tina Ayers or other greenhouse personnel when user-defined safe temperature or humidity ranges are exceeded.

4.1.2. A method shall be provided for users to add/remove alert recipients.

4.1.3. A method shall be provided to adjust temperature setpoints and any control conditions.

4.1.4. The alert will be in a concise, numerical listing of data.

4.1.5. The system will notify all alert recipients within 5 minutes of an unsafe condition being detected.

4.2. Sensor Failure Alert (Objective)

4.2.1. All alert recipients will be notified within five minutes of a sensor failure being detected.

4.2.2. At least two extra sensor modules will be left behind to allow for user replacement of failed modules.

4.2.3. Documentation will be provided so that new modules can be constructed if necessary.

5. Environmental Control Requirements

5.1. South House Air Mixing Fans (Objective)

5.1.1. At least two mixing fans shall be installed in the south house

5.1.2. Mixing fans shall be rated for wet locations.

5.1.3. Mixing house fans shall not be battery-powered.

5.1.4. The system shall be able to turn the fans on and off. At minimum, the following control modes will be provided:

5.1.4.1. Always on,

5.1.4.2. Always off,

5.1.4.3. On during user-specified hours, and

5.1.4.4. On when excessive temperature differentials are detected within the greenhouse.

5.2. South House Temperature Control (Objective)

5.2.1. **Heating Control**

5.2.1.1. The system shall control the south house glycol heater to maintain a user-selected temperature in the south house.

5.2.1.2. The temperature selection method shall be calibrated in degrees Fahrenheit.

5.2.2. **Cooling Control**

5.2.2.1. The system shall control the wet wall and south house exhaust fan to maintain a user-selected temperature in the south house.

5.2.2.2. The temperature selection method shall be calibrated in degrees Fahrenheit.

6. Packaging Requirements (Threshold)

6.1. Permanent Circuitry

6.1.1. Equipment left in the greenhouse at the conclusion of the project shall not use solderless breadboards or other temporary circuit construction techniques.

6.2. Safety

6.2.1. All equipment shall adhere to relevant safety standards.

6.2.2. Equipment operating above 12V shall comply with the National Electrical Code.

Approval

Tina Ayers _____ Date 22 Oct 2021

Emilia Connelly _____ Date 10/22/21

Ruopeng Jia _____ Date 10/22/21

Jiaxin Liu _____ Date 10/22/21

Alexia Risley _____ Date 10/22/21