NAU Teaching Greenhouse

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Abstract

This project consisted of designing and installing an environmental monitoring and control system in the NAU Teaching Greenhouse, located on North Campus. Sensors were designed to monitor the air temperature, humidity, and soil moisture content in various locations throughout the facility. Automatically controlled mixing fans were installed to eliminate undesirable temperature gradients that have caused issues for plant growth.

Requirements

- **Data Collection:** Measure temperature, humidity, and soil moisture content, every 15 minutes or less
- **Data Access:** Data must be readable over the internet, from off campus, without a VPN login
- **Alerts:** Send smartphone alerts when unsafe conditions are detected, such as cold temperatures
- **Control:** Turn mixing fans on and off based on user settings and current environmental conditions

System Architecture

The general system organization is shown below:

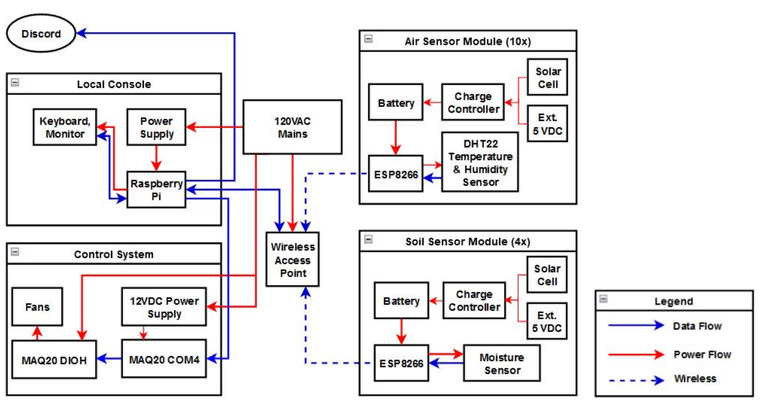

Figure 1: System Architecture

Methods

Both sections of the greenhouse have multiple sensors to monitor environmental conditions. Each sensor module is equipped with an ESP8266, a low-cost WiFi enabled microcontroller. The microcontrollers read the current conditions from their attached sensors, then report that data to a Raspberry Pi based console. Various software runs on the console to accept and log sensor data, publish that data to the web, send smartphone alerts when necessary, and generate commands for the MAQ20 system. The air mixing fans are powered by 120 VAC and controlled by a MAQ20 industrial control system from Dataforth Corporation.

Design Details

Printed circuit boards (PCBs) for both soil moisture (left) and air conditions (right) were designed in KiCAD and fabricated in-house using a PCB mill. The sensor modules are capable of being powered by an integrated solar cell, or by 5 volts DC from an external source. Because of high temperatures unsafe for lithium batteries, many of the sensors are powered by an external power supply to avoid the risk of battery fire.

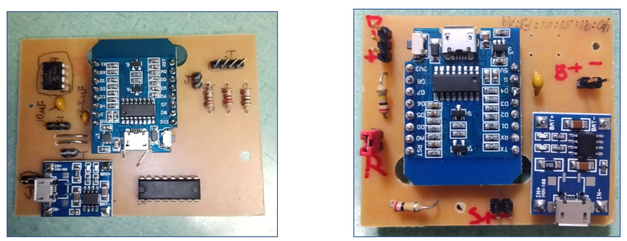

Figure 2A-B: Soil moisture and air conditions sensor PCBs

Smartphone alerts are provided by a Discord bot as shown below:

Figure 3: Discord bot issuing a smartphone alert

Testing

For testing the temperature, the sensors where placed in the most extreme temperature allowable to see if they would report the values seen in the greenhouse. The greenhouse can range from 40 - 120 °F. For the humidity, the sensors were set in environments where the highest and lowest amount of humidity were possible to ensure proper operation.

Description	Test Criteria	Result
Temperature Accuracy	Sensors accurate to ± 2 °F	OK
Humidity Accuracy	Sensors accurate to ± 5% RH	OK
Data Rate	Log data at ≤ 15 minute intervals	OK (5 minutes)
Smartphone Alert	Notify within 5 minutes	OK (< 1 minute)

Conclusion

We installed a large number of humidity, temperature and soil moisture sensors in NAU teaching greenhouse to monitor the vegetation in each area inside the greenhouse. Sensors can accurately record all data and label the data to be identified. After being monitored, the data will be recorded in the database immediately and orderly and retained indefinitely. Through the database, Our customer can check the past parameters at any time for reference. Then, the console, Raspberry Pi, will call the latest stored data in real time. The program in the controller will run logic statements to judge the greenhouse conditions in real time and upload execution instructions. Finally, the instructions are read by MAQ20 module and used to turn the air mixing fans on or off as appropriate.

Acknowledgments

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