Automated Ventilation Controller

UCF Senior Design 2021

Group 15

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Sponsored By Chris Neiger

Project Narrative:

Motivation

With the continuous advancements of technology, home automation has reached new heights. From automating blinds to open and close at certain times of the day, to receiving alerts straight to your phone when the door is left open for a set amount of time. When we conducted our first team meeting, we brainstormed about the different types of projects that we could take on that would aid our sponsor the most, and also work as our senior design project.

Our sponsor owns a warehouse full of machining tools used to make robotic equipment. The air conditioning system in the warehouse is used in conjunction with ceiling ventilation to control the atmosphere of the warehouse. The warehouse air conditioning and ventilation system is not only used for personal comfort but also for the machines. Keeping machinery cool and reducing humidity in the air is key for them to run at their optimal capacity. Our sponsor currently has an analog control system which directs the four ventilation dampers installed in the ceiling of the warehouse.

Each ceiling vent currently has a three-way switch that controls the vent's motor. The switch has three positions: the up position, down position, and the neutral position. When in the up position the roof vent opens. When in the down position the roof vent shuts. The neutral position is used to stop the vent part way. The current setup requires the user to manually control the ventilation when it is desired, which can become laborious and error prone when working with multiple machines. This is where our team's programmable ventilation controller will take charge.

Objectives & Features

The main objective of this project is to automatically control the roof ventilation system of the sponsor's warehouse. Currently, there are four, double pole double throw switches used to operate the ventilation motors with forward polarity to make the roof vents open and with reverse polarity to make the roof vents shut. To automate this, each switch will need to be replaced with four relays. The relays will act in pairs to align the motor's wiring for both forward and reverse operation. For the roof vents to open, the 'closing' relay pair will open first, then the 'open' relay pair will shut. For the roof vents to close, the 'open' relay pair will open first, then the 'closing' pair will shut. The sequence of the first relay pair opening, prior to the next relay pair shutting, is required to prevent shorting the wires and causing damage to the system.

Our team plans to build and program a unit ("controller") that automates air ventilation previously mentioned in the sponsor's warehouse, as well as monitor other environmental factors. The controller will include a Bluetooth module, where the Bluetooth module connects to multiple sensors inside the warehouse (one attached to each vent), and one outside. These sensors will be used to communicate both temperature and humidity to the main unit. The controller will also include a Wi-Fi module, where the Wi-Fi module will be used to connect a web application to the controller via a hosted server. This web application will be utilized as an alternative way to monitor and alter the vents and temperature whenever the user is not physically near the controller at the warehouse, this will allow them to change it from anywhere, as long as they have a WI-FI connection.

Thus, the main controller unit will need a local touch screen LCD display with a minimalistic interface, so that the user can easily monitor information and navigate through multiple features. The display is expected to show the average indoor temperature and humidity percentage read by the multiple indoor sensors, as well as the temperature and humidity percentage given by the 1 outdoor sensor. The user should also be able to manually set an ideal indoor temperature, as well as manage the orientation of the connected air vents (tilt up, tilt down, close) from the touch LCD (this can also be done through the web application, since both will have the same functionalities and interface). There will be an information icon at the top right of the display, which can inform the user of things like the battery life status for each sensor, the Bluetooth connection status, the Wi-Fi connection status, and the duration of how long the vents have been opened in order to track energy usage.

Goals

The data provided by the multiple indoor sensors will be used to calculate an average indoor temperature and humidity. This average will then be displayed on the screen of the main unit, along with the data read by the outdoor sensor.

Both the indoor and outdoor information will be used to determine how we anticipate automating the ventilation. The vent dampers are expected to change orientation automatically based on multiple conditions such as, a threshold temperature, an “ideal indoor temperature” set by the user, or changes in humidity. We expect to accomplish not only automate ventilation, but also optimize this ability in order to use the lowest amount of energy from the AC unit as possible. Our idea of optimizing energy usage will mainly be done by implementing a time schedule for the vents to be opened or closed. That way the user can either set the vents to be opened for only a specific duration of time, or set the vent dampers to automatically change orientation based on the environment conditions in the warehouse.

We chose to pursue this project because it was a benefit to our sponsor. This project will allow us to get more experience working with microcontroller hardware, controller programming, air circulation, as well as both the front and back end of web development. Our project will utilize Arduino parts mainly because of the high level C/C++ programming language and simple Arduino IDE. This commonly allows for more focus on the programming logic instead of worrying about the operation complexity of other microcontrollers. It's straightforward enough for beginners if all you wanna do is control electronic components (like motors, sensors, and wireless bluetooth modules) and nothing else.

We believe this programmable ventilation controller differs from all the other smart home products like Nest, because it will be built to better aid the needs of our sponsor and the personnel that utilizes the warehouse. It will, therefore, take into account more personalized energy saving approaches. It will also have a simpler user interface to make the user experience easy and intuitive. Some smart home technologies require the user to be connected to the same WI-FI network to be able to configure anything for that device, whereas our controller should allow the user to be anywhere with any WI-FI network and be able to make changes.

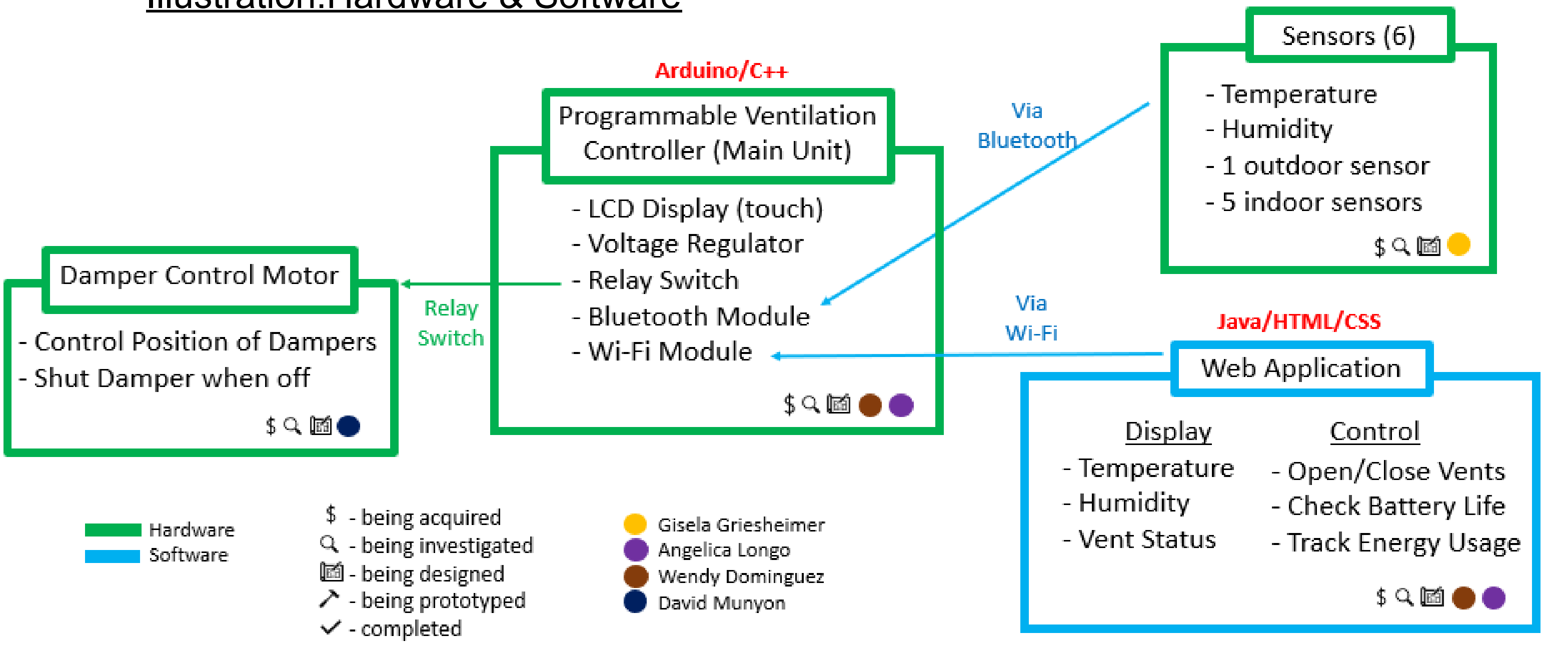
Requirements:

Obligation	Standards	Constraints	Notes
Temperature and humidity sensors	➢ Sensors will run on batteries ➢ Will be able to transmit a distance of 75 meters ➢ Will transmit data via bluetooth	Expected lifespan will be 6 months or greater	CR2 batteries can hold charge for up to 10 years in storage
Bluetooth module	➢ Bluetooth module will run off a 3.3 volt regulator ➢ Will connect temperature sensors to main control unit ➢ Expect to need 6 in total to get a good coverage of the entire warehouse	With several different bluetooth modules needed, different channels will need to be utilized to ensure proper communication	Maximum Bluetooth range is around 100 meters
Main control unit	➢ Unit will run off the power supply of the A/C controller ➢ Will run off a 5 volt regulator ➢ Will sense when A/C is running	Ensures that the AC system is not wasting energy	A/C controller is already installed at the location
LCD Display	➢ Will have touch screen capabilities for local control ➢ Will have an easy-to-read graphics	Larger LCD displays require more ports and can have lag when driven by an 8-bit module.	LCD Module should have pre-written arduino drivers to ensure proper execution
Website	➢ Will utilize a MySQL database along with PHP for the back end	The server could crash if we run out of space or the usage	Will allow the user to control the main unit from anywhere, as

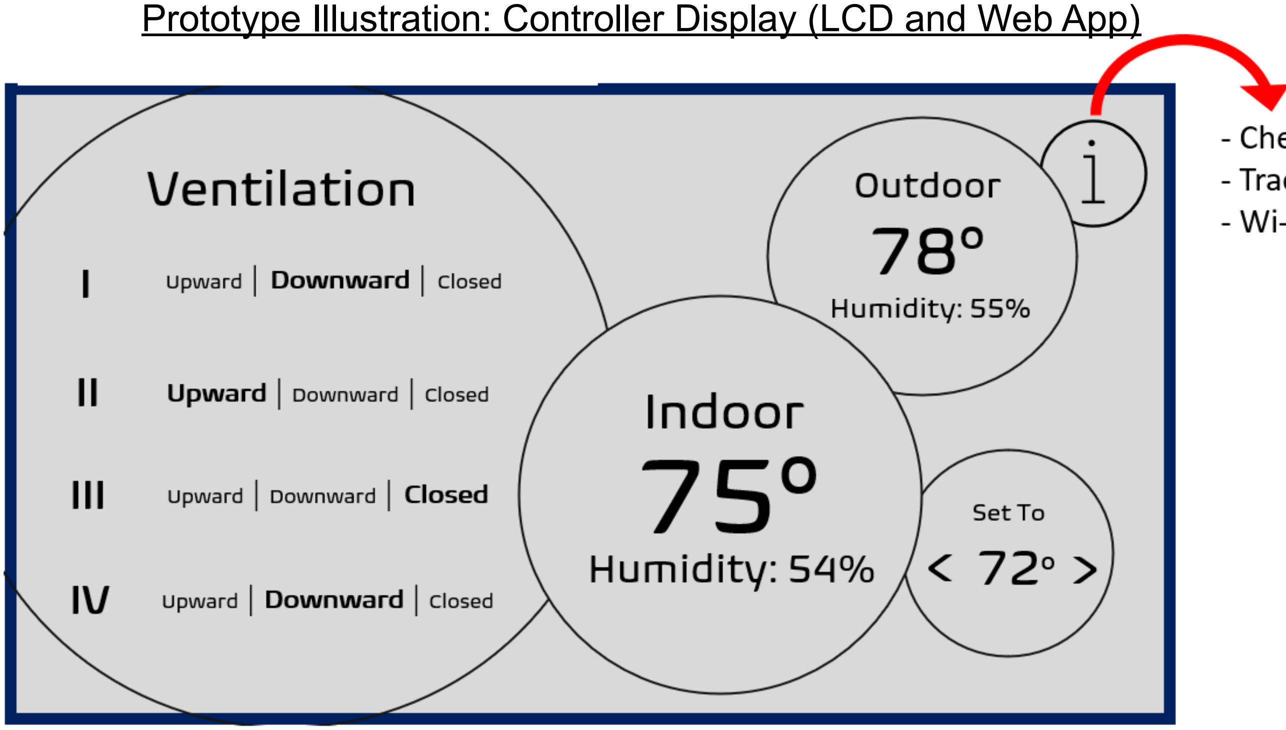
	➢ Will have a similar layout as LCD Display for controlling remotely	becomes high	long as they have WI-FI We will need to look into having a good security
Ventilation Motors	➢ Position the ventilation ports ➢ Wiring will need to be able to operate the motors in both forward and reverse	To prevent short circuits the relays will need to be normally open	Motors are already installed at location

Block Diagram:

Illustration:Hardware & Software



Prototype Illustration: Controller Display (LCD and Web App)



- Check Battery Life
- Track Energy Usage
- Wi-Fi Status

Challenges:

This section describes technical and logistical challenges presented to our group.

From a technical standpoint, we face the challenge of the warehouse being made of metal. This causes some difficulty when it comes to working with Bluetooth connectivity from the indoor controller to the outdoor sensor. In order to account for this, we intend to hardwire the outdoor sensor into the building. Regarding software, we predict to encounter complexities dealing with the implementation of Wi-Fi and Bluetooth connectivity. Thus, we propose to begin familiarizing ourselves with the application of both models as early as possible to avoid any bottlenecks in the fall.

In addition, we also need to have an automated programmed system that tells the connected vent dampers when to open, when to close, and what orientation they should adjust to, which ultimately requires an understanding of thermodynamics and air circulation. Consequently, we expect to do a significant amount of investigation to be able to program the most efficient logic commands for the vents.

From a logistical standpoint, the warehouse we will be implementing our design in is in Niceville, Florida. However, the majority of our team currently resides in Orlando, Florida. We anticipate that all our team members will still be living in Orlando during the Fall 2021 semester, which is when we intend to build and install the system for automating the vents. This will require the team to make at least one trip to Niceville during Fall 2021 to install the system, though the team is aware that more trips may be required. Additionally, Covid-19 has given us a logistical challenge in that we cannot physically meet to work on this project until Fall 2021. We plan to address this by ordering select parts early so that we can individually familiarize ourselves with the coding and assembly process as early as possible.

Financing and Budget:

For this project, we are being financed by Chris Neiger.

Estimated Budget: $1,588.60

Budget Break Down

Description	Price	Quantity	Total
Arduino Mega 2560	40.3	2	80.6
Breakout Board, ESP8266 Wifi module	7.93	2	15.86
HiLetgo HC-05 Wireless Bluetooth RF Transceiver	7.99	4	31.96
Jbtek 8 Channel DC 5V Relay Module	9.59	2	19.18
TFT 3.2" Color Touch Screen Display- ILI9341	26.98	1	26.98
DHT22 Temperature and humidity Sensor	9.95	4	39.8
Breadboard jumper wires, 120 piece	5.99	1	5.99
Breadboard- 4 piece	5.99	1	5.99
Software-Price per month	30	6	180
Assorted discrete electronic component kit	70	1	70
Final PCB build	50	1	50
Travel to/from Niceville, FL- 419 miles- 16 cents/mile	67.04	6	402.24
Hotel in Niceville, FL- $110/room/night	110	6	660
		Total	1588.6

Project Milestones: Summer

June 2	Begin writing document and researching parts
June 11	Submission Due for D&C 1.0
June 14	Project Set and approved - Meeting with Dr. Wei
June 25	Submission Due for D&C 2.0
July 9	At least half of the final document written
July 23	Submission Due for 100 Page Draft
July 31	Individual document portions complete
August 1	Edit, format, and assemble document
August 3	Submit Final Paper

Project Milestones: Fall

August 8	Order parts
September 6	Begin building design and writing software
October 18	Begin integrating software and hardware
November 1	Project fully built
November 8	Begin Practicing Presentation
December 3	Final Presentation