GreenSense

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INTRODUCTION

We have created a mobile application, that works with a database in our software engineering course. Our Internet of Things (IoT) capstone project uses a distributed computing model of a smart phone application, a database accessible via the internet, an enterprise wireless (capable of storing certificates) connected embedded system prototype with a custom PCB as well as an enclosure (3D printed/laser cut).

With our project we constructed and developed a greenhouse monitoring system. Systems like this are already available to consumers and industry professionals yet most lack certain features that many people would like to see incorporated. With our project we achieve a device that has all the features and specifications to benefit everyone. Users will be able to get up to date information on their greenhouse environment and make adjustments as necessary.

This proposal presents a plan for providing a solution for the arboretum at Humber College (Humber Arboretum, 2020) . This is an opportunity to combine the skills and knowledge that we've learned throughout our program; and create a capstone project demonstrating our abilities. Such a system will improve on the current system and provide the staff at Humber's arboretum an easier, more efficient solution to maintain the greenhouse from anywhere.

AIM

This project utilizes various parts/components to add the needed functionality to the device. The first sensor is the BME680, which is responsible for taking in readings such as humidity and air quality (VOC gases). Next, this project includes a Gikfun EK1940 capacitive soil moisture sensor, which is responsible for reading moisture levels in the soil of various plants. Lastly, the third sensor we will be using is the DS18B20 sensor, which measures the temperature inside the greenhouse. Along with these three sensors we have also included: an SG90 servo and case fan for a ventilation system, a 28BYJ-48 stepper and ULN2003 driver board to rotate a sunshade system, and a Gikfun EK1856 diaphragm pump for watering the plants. The physical designs of this project required use of software such as Fritzing, openSCAD, and CorelDraw. Programming was done using Java in Android Studio, Python on the Broadcom platform, and the database using Amazon's Firestore. Physical assembly of the PCB and scale model greenhouse required external resources such as PCB manufacturing (Humber prototype lab), 3D printing, and laser cutting (substituted); and tools such as a welder, grinder, soldering iron, drill, rotary tool, and various hand tools. For a more detailed list of parts, suppliers, and tools please see our Github report: https://github.com/Aidenbolos/Green-Sense/tree/master/Documents/CENG%20355/Report. This project was built by 3 group members with approximately 50-60 hours in design/documentation, 45 hours in fabrication/assembly, and 20 hours in programming.

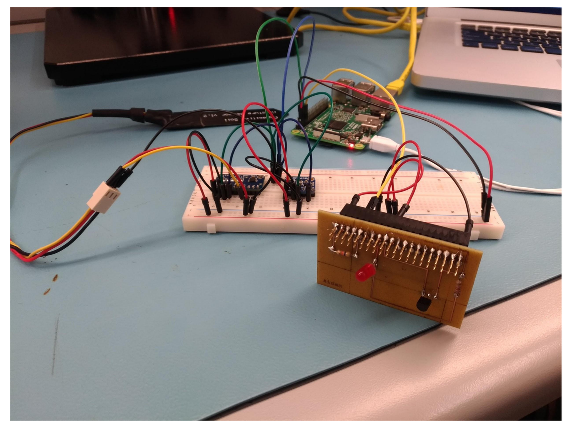
METHOD

We began by breadboarding all our individual sensors together in order to work toward a permanent/production-level solution. The answer to this was to design a custom PCB. We then designed and edited a custom PCB using Fritzing. This was done by selecting board dimensions, drawing traces, inserting vias, and placing holes for headers/components.

Once the PCB was designed and approved by the Fritzing software, the design was exported as a Gerber file. This file was then sent to the Humber Prototype Lab for the PCB to be made. The Prototype Lab uses the LPKF ProtoLaser ST and the LPKF ProtoMat S103 to create these custom PCBs.

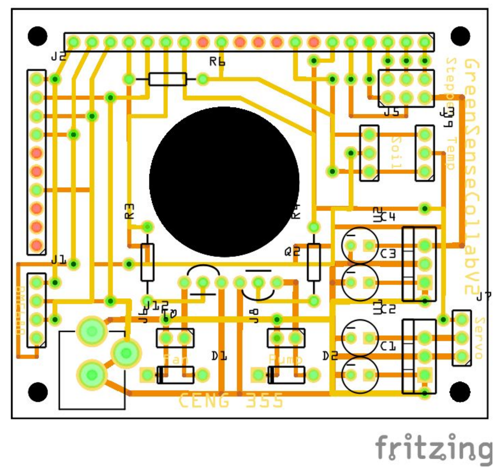
The freshly made PCB was the assembled and soldered using headers, aDC jack, resistors (1k and 4.7k), transistors (PN2222A), diodes (1N4007), capacitors (0.1uF and 1uF), and 7805 voltage regulators. With the PCB fully assembled, we double-checked all solder joints and connections, as well as tested the circuit with a multimeter. When everything checked out, we installed the PCB onto the Raspberry Pi for the power up test.

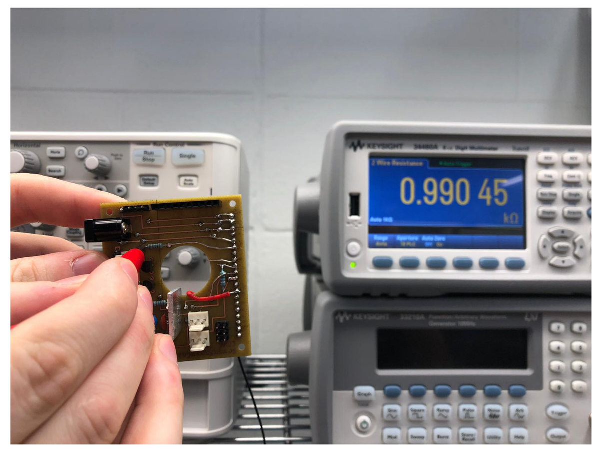
We used SD Card Formatter and BalenaEtcher to load the Raspbian operating system. VNC Viewer/Server allowed us to remotely control the Raspberry Pi from our computer. We used Python code/libraries to measure temperature, humidity and moisture levels from the 3 sensors; and to control the 3 effectors.



Breadboarding all three sensors together before moving on to the PCB stage.

GreenSense PCB combines three sensors and three effectors. This work is a derivative of "http://fritzing.org/parts/" by Fritzing, used under CC:BY-SA 3.0.

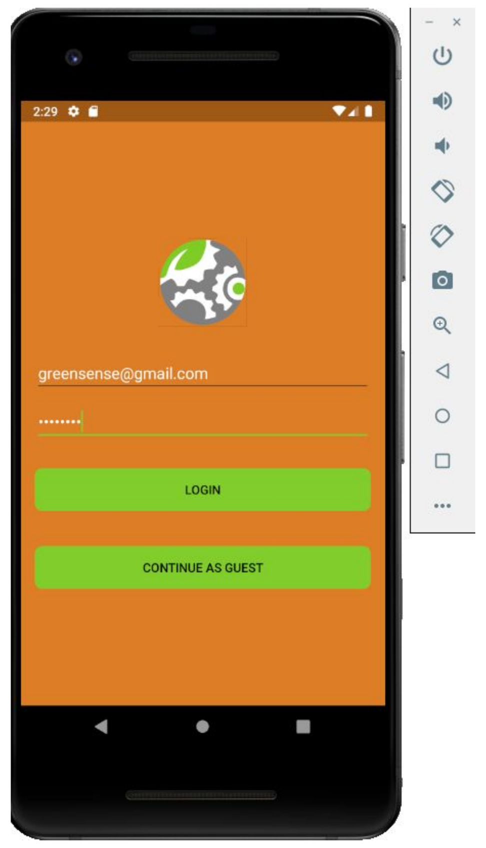




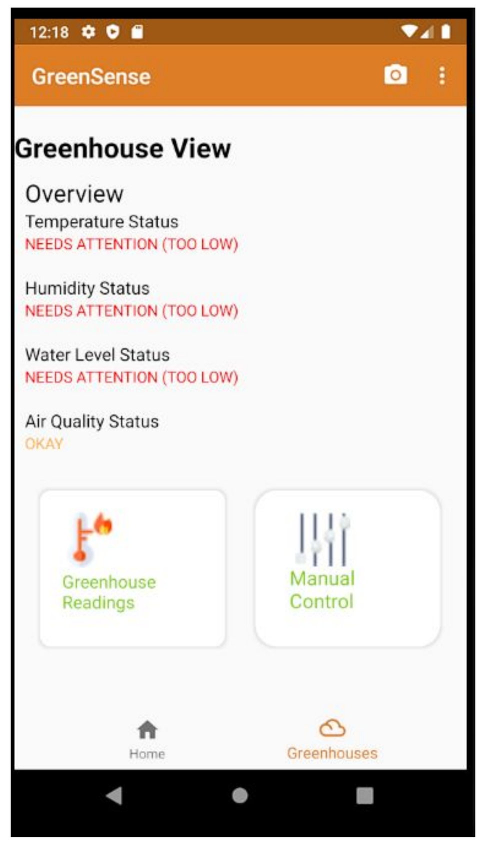
Testing the PCB (3,2020) taken by Ryan McAdie.

RESULTS

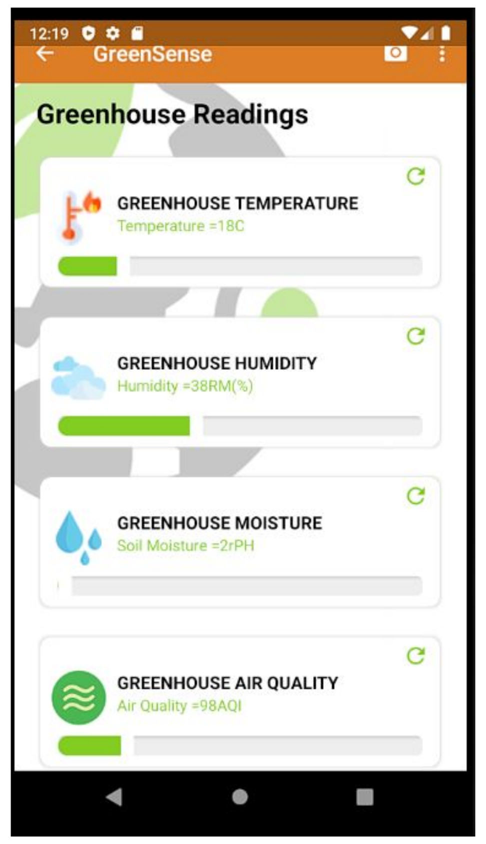
For the entire duration of semester 5 (September 2019 – December 2019) we worked on developing an Android application that was capable of connecting with a database to allow for retrieval of information. We ended up hosting our database using Amazon's Firestore. Users are able to login using credentials that are stored securely in the database. Users can then choose which greenhouse they would like to view/manage (accommodates more than one). From there, users can access the values that are stored in the database representing temperature, humidity, air quality, and soil moisture levels. This means we have an active connection to our database. Data read/writes were programmed to stay within Firestore's requirements (50k/day reads, 20k/day writes). There is also a page where users are be able to make adjustments to the environment remotely using the various effectors. All of this ensures the plants are in a safe and optimal growing environment.



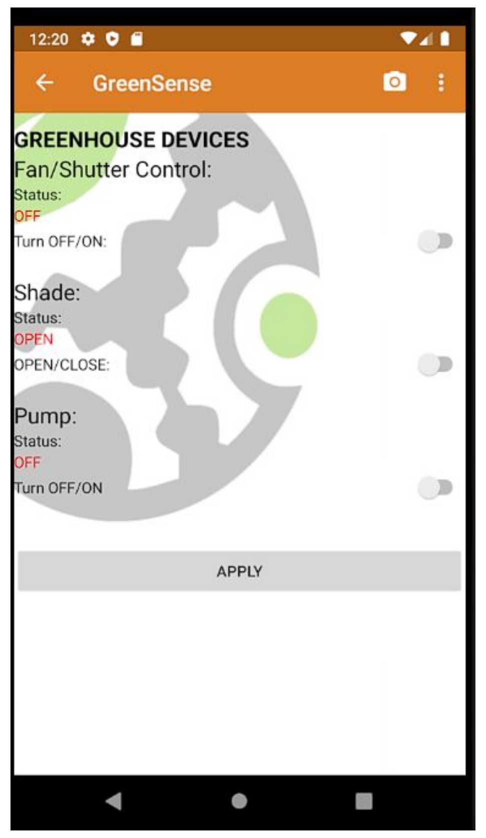
Android Studio. (2020). Screenshot from login page of GreenSense mobile application.



Android Studio. (2020). Screenshot from greenhouse overview page of GreenSense mobile application.



Android Studio. (2020). Screenshot from sensor readings page of GreenSense mobile application.



Android Studio. (2020). Screenshot from effector control page of GreenSense mobile application.

PRINTING

We decided to make a scale model greenhouse to showcase our sensors and effectors. Various components of the scale model were made using a combination of 3D printing, acrylic laser cutting, and welding/metal fabrication. 3D print models were designed using openSCAD, acrylic designs using CorelDraw, and metal fabrication designed on-the-fly. The main body of the Pi case was 3D printed and features: an acrylic door with a mounted fan for cooling, an acrylic sliding cover for the ethernet/usb, and a wire channel at the bottom. The scale model greenhouse has a custom fabricated metal outer frame and acrylic panels for the walls and roof. Due to the closing of the college/prototype lab, 1mm clear PP (Rubbermaid bin) was used as a substitute for acrylic. The clear plastic was cut by hand with an exacto knife and holes/notches were made with a drill or rotary tool. Various subsystems within the scale model greenhouse were also custom made: a 3D printed shutter system for air intake, a 3D printed housing for a stepper motor/driver board, 3D printed pillow blocks/bearing mounts, and a roller shade system.

Complete greenhouse showing fan/shutter system.

Pi case for greenhouse. Acrylic door open showing cooling fan and wiring.

CONCLUSIONS

Our system is one of the first of its kind to implement a majority of the necessary features of a greenhouse monitoring system. This system goes above and beyond to achieve features and requirements that make managing a greenhouse a little easier; and provides peace of mind knowing that the health of your plants is taken care of. Our next steps will involve further improving upon the physical designs/components, updating and maintaining the code/database, as well as preparing a plan for moving this system into production for client purchase.

ACKNOWLEDGEMENTS

Humber Arboretum. (2020). Retrieved from Humber Arboretum and centre for urban ecology: https://humber.ca/arboretum/