GrowIoT Smart Greenhouse

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**Computer Engineering Culminating Project**

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**Introduction**

***Creation***

As a culminating project for my grade 11 computer engineering class, I decided to take on the challenge of creating something from the ground up. After some thinking, I decided to combine my love of gardening and computer technology to create this project – The GrowIoT Smart Greenhouse.

**A picture containing electronics, electronic engineering, electrical wiring, circuit component

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*Figure 1: Early workings of the Greenhouse*

***Goals of the Project***

Upon deciding on my project, I laid out two main goals – develop the greenhouse to have as many self-sustaining features as possible, and display collected data over the internet to be accessed from anywhere. I also wanted to make this for cheaper and better than other smart greenhouses/growing devices that could be had on the internet.

A plant growing in a planter

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*Figure 2: An example smart greenhouse for sale*

**Hardware Used**

***Parts List***

|  |  |  |
| --- | --- | --- |
| **Part Name:** | **Usage:** | **Subtotal (CAD):** |
| ESP32 Dev-Module | Microcontroller powering the logic of the project. Similar to Arduino devices but with WiFi and Bluetooth capabilities. | $4.02 + $1.84 shipping = $5.86 |
| DHT11 Temperature and Humidity Sensor | Low-cost sensor able to detect temperature and humidity of greenhouse. | $2.99 |
| Capacitive Soil Moisture Sensor | Reads moisture of the soil | $0.99 + $1.42 shipping = $2.41 |
| 8A Buck Converter | Allows for 12V power rail that can also be stepped down to 5V for different devices. | $2.78 + $2.33 shipping = $5.11 |
| 12V Water Pump | Used for self-watering the plants and is submersible. | $3.09 |
| PVC Plastic Hose 8mm ID 10mm OD | Hose for moving the water coming out of the water pump, | $0.53 |
| 1M WS2812B 5V ARGB LED Strip | The ARGB in this LED strip allows for a light spectrum ideal for plants to be used. | $19.99 |
| 12V 5A Power Supply | Supplies power to the greenhouse. | $24.99 |
| 0.96 Inch OLED Display | Outputs data physically. | $1.92 + $1.66 shipping = $3.58 |
| 60-L Transparent Bin | Enclosure of the greenhouse. | $14.99 |

***Price List***

Subtotal: $83.54 CAD

Total (HST 13%): $94.40 CAD

The pricing of this project, specifically making it low-cost yet still high-quality, is something I am rather proud of. This greenhouse can be replicated by others for approximately *~$100 CAD* total. Compared to other smart greenhouses that can be purchased online for *~$120 CAD* subtotal, this greenhouse features drastically more features. For a greenhouse that can be purchased online in that price range, one may expect features such as an automatic lighting timer.

A picture containing herb, vegetable, leaf vegetable, lettuce

Description automatically generated *Figure 3: A smart greenhouse with self-watering features*

The smart greenhouse pictured above has self-watering, but is $259.99 CAD. The GrowIoT Smart Greenhouse not only features just automatic lighting and self-watering, but a ventilation system that is controlled based on temperatures, temperature, humidity, and soil moisture logging – all of which can be accessed from a phone.

**Circuitry**

***Circuit Diagram***

The wiring for the greenhouse was done on a solderless breadboard but may also be created on perfboard or a custom made PCB. Refer to wiring below:

A picture containing diagram, technical drawing, plan, schematic

Description automatically generated

***Soldering Devices***

Minimal soldering was required for this project, although there is one main component. For the LED strip, it was cut into 4 sections, and daisy chained together as the LED strip has both power in and power out. In further developments of the greenhouse, there are plans to use perfboard to solder the components together in a more refined manner.

**Software Development**

***Arduino IoT Cloud***

The Arduino IoT Cloud is the piece of software that allows for the transfer of data collected by the ESP32 to the cloud which can be accessed from anywhere. It is a software that is free with limitations, although for this project, the “Entry” plan was what I used, which came out to $26.98 CAD total for a year. It allows far more variables to be used and allows for overall better functionality.

It is a very powerful tool, which functions using cloud variables that are similar to Arduino with basic types like integers or strings, as well as special variables like time. Another feature it has is the creation of dashboards, which can have outputs like gauges, charts, and schedulers, giving the project a clean and easy way to read data.

A screenshot of a computer

Description automatically generated with low confidence

*Figure 4: Arduino IoT Cloud dashboard for the greenhouse*

This can all be programmed in the cloud with a built-in web editor, which can save sketches to be accessed across any devices. Once a device is connected to the internet, there is also the capability to upload sketches via the cloud, without the use of physical serial ports.

***Programming***

Within the Arduino IoT Cloud’s web editor, the greenhouse was programmed. In other projects I’ve made, I would apply the use of functional programming paradigms, but much like other aspects in this project, I wanted to create a challenge. This is where I chose to implement object-oriented programming, creating classes for different aspects of the code. For example, I created a data collection class that features the code needed to read all the sensors, making the program more efficient and easier to understand.

A screen shot of a computer program

Description automatically generated with low confidence

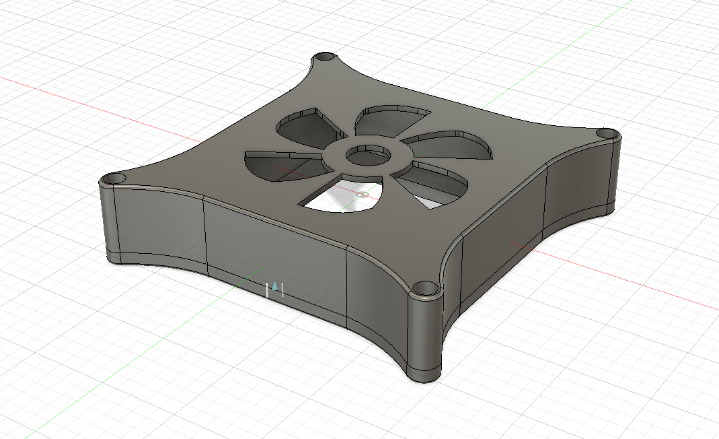
*Figure 5: Example code of the data collection class*

The implementation of object-oriented programming not only provided an extra challenge, but it was a great learning opportunity, and overall, it increased the quality of the code.

**3D-Design**

***Design of Parts***

For the attachment of some parts such as the fan, special mounts needed to be designed. More aesthetic parts were also designed, such as a name plate, or a vent plate. This design was done using Autodesk Fusion 360, which is a powerful 3D-design software that is easy to use. All these parts were then 3D-printed and secured to the greenhouse using nuts and bolts.



*Figure 6: Fan mount plate used to secure fan to the greenhouse and ventilate air*

*A picture containing screenshot, rectangle, box, design

Description automatically generated*

*Figure 7: OLED display holder mounted to the top of the greenhouse*

***3D-Printing***

Once all these parts were designed, they were fabricated at home using a modified Ender 3 Pro desktop 3D printer. The overall print time for all the parts was approximately 30 hours. Due to not needing strength out of these parts, with the main requirement being ease of printing and aesthetics, all the parts were made using PLA filament.

A picture containing waste container, plant, outdoor, container

Description automatically generated*Figure 8: 3D-printed parts being put to use in the greenhouse*

**Enclosure Creation**

***Ventilation & Drainage***

Given that plants are growing inside the greenhouse, proper ventilation and drainage had to be put in place. For water drainage, a drill was used to drill out small ¼” holes at the bottom, allowing for water to seep through the soil and drain out. For ventilation, the fan was placed inside the printed fan mount, then holes were drilled out to bolt it to the side, and a cutout was made so the fan would ventilate the greenhouse and intake fresh air.

An oversight that was made was not including an exhaust fan, although ventilation holes were made through the printed vent plate. This could be an added feature later on, although early findings indicate that cooling/ventilation performance is good. For instance, in testing the greenhouse, the relative humidity reached as high as 80%, although once the fan kicked in and started venting out air it dropped to 65% in a matter of minutes - which is substantially better for plant growth. A screenshot of a graph

Description automatically generated with low confidence

*Figure 9: The reductions in temperature and humidity correspond with when the greenhouse ventilation fan kicks on, indicating its efficacy*

***Final Assembly***

Upon bolting components like the fan and ventilation plate onto the greenhouse, there were still all the other components left. The ARGB LED strip was taped to the lid of the bin used for the greenhouse in 4 different sections. A hole was then drilled in this bin to route the wires through.

A picture containing light, indoor

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*Figure 10: LED strip daisy chained and taped down to the bin of the greenhouse*

The DHT11 temperature and humidity sensor was connected by drilling a hole through the bin and putting a screw that would secure it, with the wires for it routing through their own individual hole in the bin. The soil moisture sensor was stuck into the dirt, with its wires routing through the same hole the LED strips wires went through.

For the water pump, and the reservoir it drew from, that was placed directly next to the greenhouse, with a hole being drilled through the side of it to put the water hose through.

To secure the breadboard down, which is where everything connects to, it was taped down on the top of the greenhouse in a place where all the wires could reach. Although this solution is not the cleanest, it still works. This is another motivation to solder the circuit onto perfboard, which can then be neatly put into a 3D printed case, with no risks of wires coming loose.

With that, it completes the assembly and creation of the GrowIoT Smart Greenhouse, my culminating for this computer engineering class!

A picture containing car, floor, light, indoor

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*Figure 11: The GrowIoT Smart Greenhouse working at night*

**Conclusion**

***Key Takeaways***

This project was amazing to work on, and I am very fortunate to have had the opportunity and resources to be able to see an idea I had a few months ago become reality. There were many obstacles I faced and had to overcome, and here are some, just to name a few:

* Sensors would work without WiFi connection, stopped working with a connection
* Sensor data was outputting values in the thousands for a temperature reading
* ESP32 connection issues to the cloud
* ESP32 no longer powered on via USB power

At the time, these obstacles were all quite confusing and even frustrating to me, but they all taught me great lessons in problem solving skills and learning to search through resources to find answers to a problem one may be faced with.

I also learned how to work with new things I had never worked with before, such as an ESP32, or this being my very first IoT project, which has started an interest in developing other IoT projects in the future.

All in all, this project was a great way to further develop problem solving and technological skills, but also to spark a new interest in an aspect of technology I had not yet explored. This project should also allow me to grow fresh plants all year round – which is my favorite part!

***Acknowledgements***

Creating this project would not have been possible without the support of the amazing tech teachers, and I would like to thank them for always be willing to help me along the way of this project. Whether it be a programming issue, certain hardware not working, or digging through the machine shop for a very specific type of screw, they were always there to support this project, and for that, I thank them.