Divide and Conquer 2.0

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Wifi Hydro Garden

An automated hydroponics system with integrated Wi-Fi that you can monitor with your phone.

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1.0 Project Narrative

As a consequence of living in the Digital Age, all the information about food that you eat can be found online. Unsurprisingly, this has led to a variety of concerns regarding the quality of produce that are sold in grocery stores. Worries about pesticide usage and genetically modified organisms (GMO’s) have helped push more and more people to growing their fruits and vegetables locally. However, the act of enveloping oneself in the art of horticulture is no easy task. For the majority of people, the lack of knowledge and experience in this field coupled with the stereotypical back-wrenching labor provides an ample deterrent in attempting to grow produce at home.

The Wi-Fi Hydro Garden seeks to lower the amount of skill required to enter this growing consumerist hobby and enable a wide range of people to yield fruits, vegetables, and herbs all from their own home. While horticulture as a whole involves a variety of methods to grow plants, the Wi-Fi Hydro Garden is a strictly hydroponics-based system. The benefits that exist from using hydroponics include more efficient use of water and space, decreased harvest cycle time, and lack of pesticide usage. Hydroponics also has a variety of quantifiable data that can be measured and used for information regarding the performance of the growing operation. For the most part, using a hydroponic system checks all the boxes when considering simplifying the home growing process.

Despite the benefits that hydroponics presents, setting up such a system still requires a fair amount of knowledge and research in the field itself. Continuing on with the ease-of-use philosophy, the Wi-Fi Hydro Garden will also fully automate all necessary features to keep the hydroponics system running in ideal conditions. By continuously monitoring the pH levels, nutrient content, humidity, and temperature within the garden, appropriate feedback can be generated and sent to the subsequent control systems. When required, the Wi-Fi Hydro Garden can control the lights, pumps, fans, and bubblers to ensure that all monitored data is within adequate ranges. In addition, the plant enclosure will feature internet connectivity to provide a direct link to the Wi-Fi Hydro Garden mobile app. Furthermore, the user will be able to see real-time pictures of the growing process at any point through a camera alongside continuous updates of all data being monitored. All data recorded will be saved through AWS cloud storage, reducing the native memory requirements and providing metrics for performance analysis. The hope is that providing remote access to information about the Wi-Fi Hydro Garden’s operational status will create a stronger willingness for users to commit to home growing produce.

Automating hydroponic-based systems is not ground-breaking science, there are several automated systems that many people own themselves. However, it is important to note that many of these systems are in favor of a do-it-yourself approach. Many automated solutions simply sell a microcontroller and require the customer to build their own enclosure for growing. Removing all the work and effort that comes with growing plants locally is the main priority of the design, and with that involves the setup for automation. The Wi-Fi Hydro Garden seeks to provide a relatively modular and refined system that attempts to have little to no user input outside of initial setup.

2.0 Requirements Specifications

- The grow enclosure will be no taller than 6 ft.
- The grow enclosure will be no wider than 3 ft.
- The system will have no less than 10 gallons of supply water.
- The system will have 3 individual liquid storage containers for pH Up, pH Down, and nutrients.
- Each liquid storage container will have no less than 500ml of storage capacity.
- The system will have a PCB with an integrated Wi-Fi and BT module.
- The PCB will run on 12 to 3.3 VDC.
- The PCB will control relays to power on and off the lights and pump.
- The system will send sensor data via Wi-Fi to a data storage system in the cloud every 60 seconds.
- The system will send pictures via Wi-Fi to a data storage system in the cloud every 10 minutes.
- The total cost of the build shall not exceed $1300.
- The system will interface with a custom iOS app that will display pictures and sensor data.
- The cloud storage system will have no less than 5GB of storage data.
- The system will be able to grow 12 plants at one time.
- The system will be able to return the pH balance of the water back to specified levels in less than 1 hour.
- The system will be able to return the nutrient level of the water back to specified levels in less than 1 hour.
- The system will have at least one fan to control temperature and humidity.
- The system will be able to restore temperate and humidity levels to required parameters in less than 30 mins.
- The system will have full spectrum lighting to include 380-780nm wavelengths.
- The Power Supply will receive 120V 60 Hz AC and convert to 12V DC.
- The system will have a minimum water protection rating of IP 63.
- All PCB circuitry will run on less than 500mA of power.
- The microcontroller will operate at a frequency of no less than 16MHz.
- The system will take a Butter Lettice from seed to harvest in less than 30 days.
- The system will be completely enclosed so that we can control the amount of light the plants will receive.
- The iOS app will notify the user if there is a system malfunction is less than 60 seconds.
- The entire system will run on less than 10A of power.
- The lighting will be no less than 24” above the base of the plant growth.
- The lighting will supply at least 300 PPFD to entire growth area.

2.1 Constraints

Size:

- This will be an indoor unit so size is a consideration. We will keep our project to 15 or less plants

Noise:

- As an indoor project we will be mindful of noise from fans and pumps. Our goal is to keep max operating volume below 35dB

Safety:

- This Hydroponics system will be mixing water and electricity which is obviously very dangerous. PCB and all cables must be shielded from water intrusion. We will have a minimum IP rating of 64

Cost:

- Preliminary estimates of parts and materials are very high but we are not rich. We aim to keep this project under $1300.

2.9 House of Quality

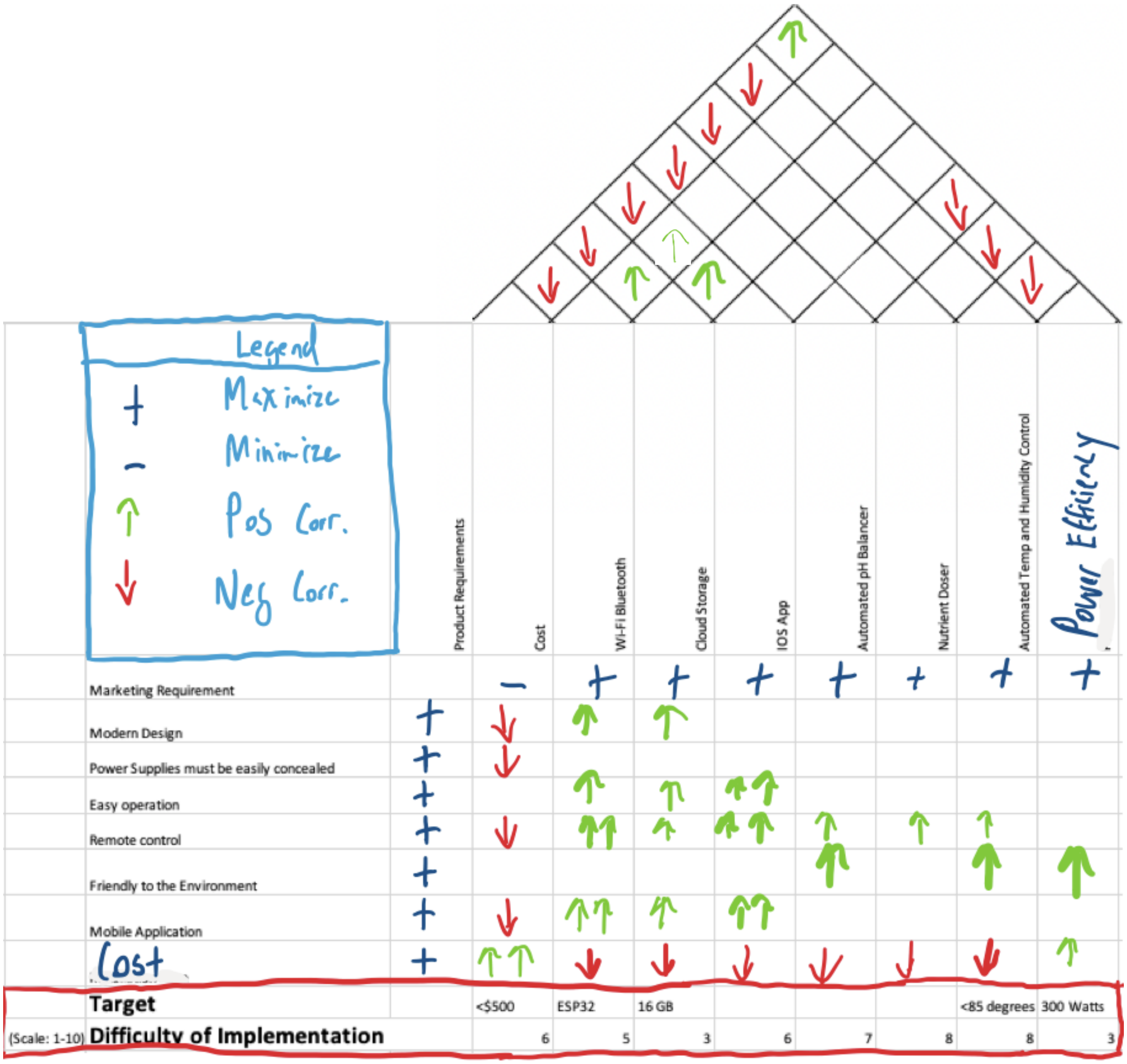

Table 1: House of Quality

3.0 Project Research

3.7 WiFi/BT Module

For this automated WIFI hydro-garden one of the key features needed is for it to have Wi-Fi/Bluetooth capabilities because the garden is going to work closely with the app and the user needs to be able to access this at any place, at any time. For this to work the hydro-garden must be able to connect to Wi-Fi, and on top of this It must be able to send the information receive from the garden to the app via Wi-Fi. It must also be able to transfer data to the cloud at a fast enough speed that would be acceptable to the user. To do this, the plan is to use a Wi-Fi and Bluetooth Module which can give most microcontrollers access to a Wi-Fi network, giving the users the ability to connect directly to their garden system.

The WiFi Module that we are considering must be able to connect to Wi-Fi signals using the ESP32, which is for task such as voice encoding, music streaming and MP3 decoding. This should be just fine for the Bluetooth module as we are not streaming or doing any voice encoding or MP3 decoding. The Wi-Fi modules that are currently being considered are ESP32 WiFi-BT-BLE MCU Module / ESP-WROOM-32 that is being sold on adafruit.com for $8.95 and HiLetgo ESP-WROOM-32 ESP32 ESP-32S Development Board 2.4GHz Dual-Mode WiFi + Bluetooth Dual Cores Microcontroller Processor Integrated with Antenna RF AMP Filter AP STA for Arduino IDE being sold on amazon.com for 10.99. The part that is being chosen is the HiLetgo ESP-WROOM-32 ESP32 ESP-32S Development Board 2.4GHz Dual-Mode WiFi + Bluetooth Dual Cores Microcontroller Processor Integrated with Antenna RF AMP Filter AP STA for Arduino IDE because of its availability and ability to receive the part as soon as possible.

3.8 pH Sensor

This garden systems' success is going to heavily depend on the nutrients that each plant receives as the plants are receiving water and other nourishment. Nutrients can also build up within the system and solidify causing the user to have to clean the system as this would happen periodically which in this case would minimize the automation feature that is going to be very crucial within this hydroponics garden, but if the pH system of the water going into the hydroponic sensor is monitored via a pH sensor it will keep this discrepancy from occurring. The way this is going to be monitored is via the pH sensor, which is supposed to determine the acidity level of the water that is going into the hydroponic garden. This is measured based on a logarithmic scale from 1 to 14 with any value lower than 7 being an acid an any value higher than 7 would be a base. For most plants the optimum pH range is from 5.5 to 7.0 but some plants will grow in more acid soil or may require a more alkaline level. So, for this system the pH sensor will need to be able to sense if the pH range is anywhere from 5.5 to 7.0 consistently without the user having to constantly interact with the sensor. Since it is essential to keep the system automated, paper pH level tester will not be used even though they are cheaper to use. This would require the user to have to check the pH level constantly themselves which can get tedious if the system is supposed to be automated. Another way to do this is Via a pH electrode probe. The pH probe is a hydrogen ion sensitive glass bulb, with a millivolt output that varies with the changes in the relative hydrogen ion concentration inside and outside of the bulb. This probe is attached to a BNC cable and then is connected to a sensor module and the sensor will be used by having the probe placed into the reservoir and have it read the pH levels of the water constantly. With there are two parts that are being considered for this. The first part is the Gravity: Analog pH Sensor Meter Kit which is which is being sold on Arduino.cc for 29.50. The other part is the GAOHOU PH0-14 Value Detect sensor Module and PH electrode probe BNC for Arduino which is being sold for 35.99 on Amazon. The part that will be chosen will be the GAOHOU PH0-14 Value Detect sensor Module and PH electrode probe BNC which is sold on Amazon because of its wide availability, and speedy delivery.

3.9 Camera

In order to effectively provide a remote viewing experience of the growing operation, having a quality camera is essential. The camera will primarily be used to take periodic photos of the plants inside the growing chamber and provide the user with the ability to see a live photo of their hydroponics system at any time. The camera may also be used for the features required from the camera involves having a good resolution and Field of View. In our research, we concluded that there are two camera sensors that fit our requirements alongside budgetary constraints.

3.9.1 Sony IMX219 Image Sensor

The Sony IMX219 is a diagonal 4.60 mm CMOS active pixel type image sensor with a square pixel array and an effective pixel count of 8.08 million. For communication purposes, the sensor supports 2-wire serial communication and a CSI2 serial data output (either 4 lane or 2 lane). This chip contains a variable 8/10 bit RGB RAW output for images. In addition, the chip features a 10-bit A/D converter and a data rate of 755 Mbps/lane for 4 lane data output, or 912 Mbps/lane for 2 lane data output. Having a high rate of data output is key since the camera in our design will constantly be taking photos, and potential videos.

3.9.2 Arducam OV5647 Image Sensor

The Arducam OV5647 is an image sensor built to primarily be an accessory for the popular Raspberry Pi development board. This sensor has an effective pixel count of 5.04 million, offering various image quality options from the get go, including a range of resolutions from QSXGA to QVGA. This chip contains a variable 8/10 bit RGB RAW output for images.

Specification	Sony IMX219	Arducam OV5647
Megapixels	8 Megapixels	5 Megapixels
Resolution	3280 x 2465 pixels	2592 x 1944 pixels
Board Size	25 mm x 24 mm	25 x 24.5 mm
Maximum Image Transfer Rate	30 FPS @ QSXGA	15 FPS @ QSXGA

4.0 Block Diagrams

4.1 Hardware Diagram

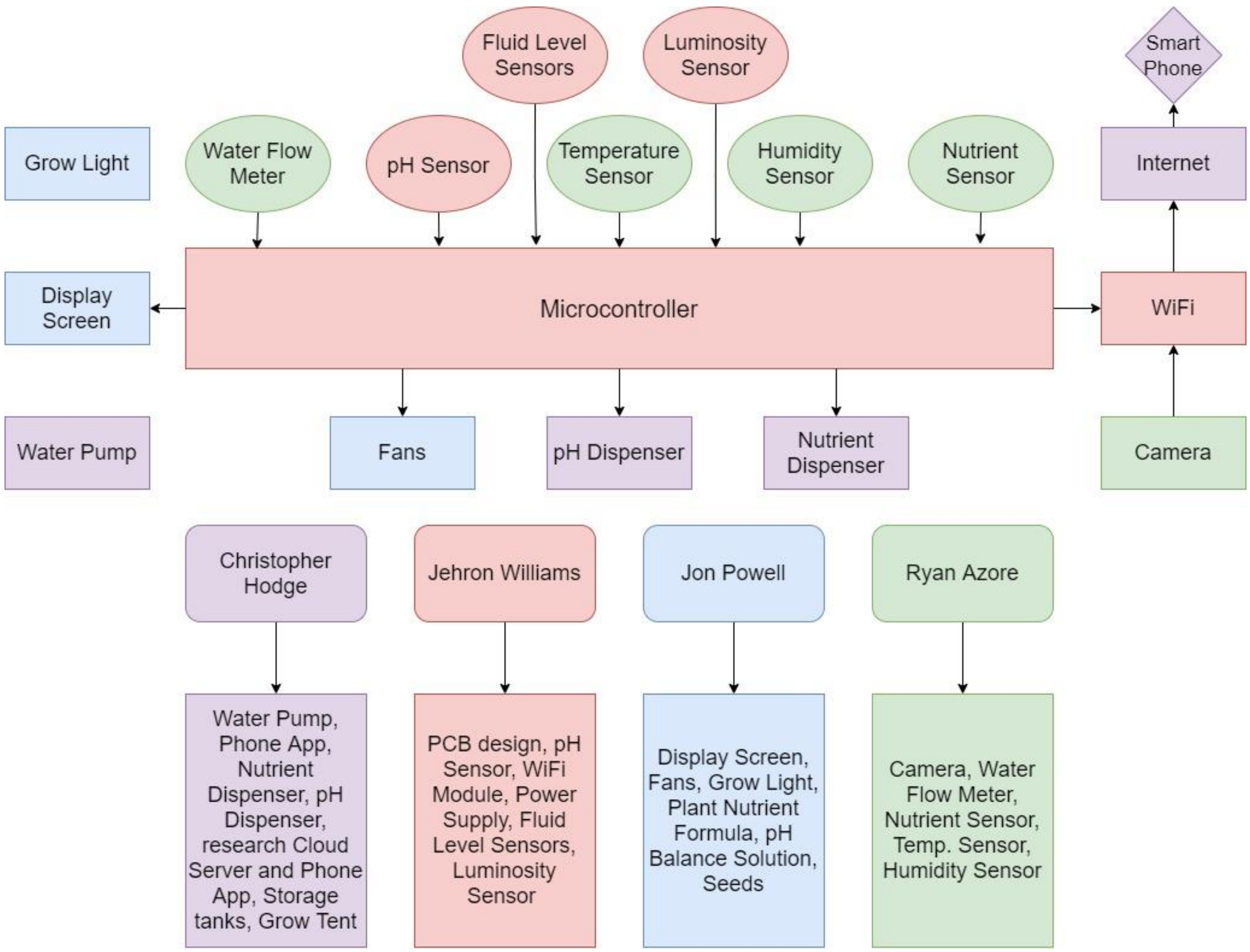

Fig 1: Hardware Diagram

4.2 Software Diagram

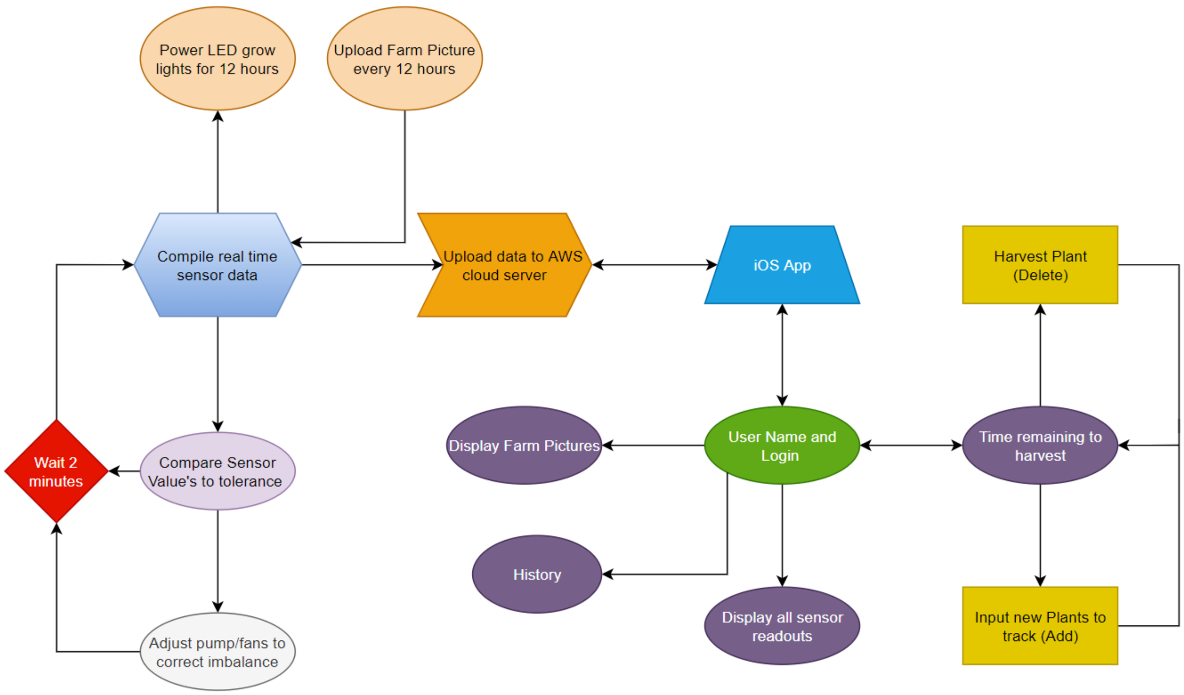

Fig 2: Software Diagram

5.0 Estimated Project Budget and Financing

Before diving into the project's estimated budget, it is worth noting that the project's budget will be self-funded and not funded by a sponsor. The total cost will be divided evenly among all of the members. The total cost will contain the cost of any parts along with an added emergency fund at the end of the table to account for any complications that had to be funded such as, parts breaking, parts malfunctioning, or any parts that were not accounted for before.

Part	Estimated Cost
PCB/Microcontroller	$15
Water Flow Meter	$100
ph sensor	$40
Temperature Sensor	$65
Humidity Sensor	$15
Nutrient Sensor	$225
Water Pump	$20
Fans	$25
Nutrient Dispenser	$55
WiFi Component	$10
Camera	$30
Grow Tent	$80
10 Gal. Tote Box	$25
LED Grow Light	$100
Power Supply	$100
Plant Nutrient Formula	$35
pH Balance Solution	$20
Seeds	$5
Miscellaneous*	$100
Emergency Fund	$200
Total	**$1,265**

*Miscellaneous includes building supplies like piping, hoses, wires, etc

Table 2: Estimated Cost.

6.0 Project Milestones

The overall project is broken into smaller tasks, within the Project Milestones table, that needs to be completed over the next two semesters. Those different tasks also include the due date and who is responsible for the completion of them. This allows the group to physically see what is left to accomplish and when they need to be accomplished by.

Senior Design I		
Task	**Due Date**	**Responsible**
Form Group	05/20/21	Group 11
Project Idea	06/01/21	Group 11
Initial Project Document	06/12/21	Group 11
Idea Review w/ Professor	06/15/21	Group 11
Update Initial Project Document	06/25/21	Group 11
Order Test Components	06/30/21	Group 11
60 Page Document	07/09/21	Group 11
Test Components	07/10/21	Group 11
100 Page Document	07/23/21	Group 11
Final Document	08/23/21	Group 11
Senior Design I Finished		
Senior Design II		
Order PCB	TBD	Group 11
Order Parts	TBD	Group 11
Hardware Check	TBD	Jon, Ryan
Software Check	TBD	Christopher, Jehron
Manufacture Prototype	TBD	Group 11
Test Final Product	TBD	Group 11
Product in Working/Presentation Condition		
Final Presentation	TBD	Group 11

Table 3: Project Milestones