Portland State University
Maseeh College of Engineering and Computer Science
Electrical and Computer Engineering Department
ECE 212 - Introduction to Project Development

ESP32-Controlled Hydroponic System

All team members have contributed to this report, read it, and agree with its contents

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I. Executive Summary

The goal of this project was to create a plant-growing system with controlled water (called hydroponics) to make growing small plants in the home easy. We really wanted to make it easy to reproduce with 3d printed parts that can be printed on most small hobby machines or sourced from a company that does 3d printing. We wanted this project to be able to conform to whatever space constraints the user has. We did this by making it out of modular pieces similar to lego/ this lets the user build it as tall as wants or as short as 2 blocks. From there we wanted the possibilities to be endless. For the less technically inclined it could end there with just a water pump to move water and a tower to hold plants. However, we wanted to give an example of some of the options that you could do. We wanted to have sensors for more accurate data on the plants we are growing.

II. Motivation

a. Need

For this project, we all agreed universally that we wanted to do something that mattered. Something that can have a tangible impact on our society whether it be indirectly or directly. we wanted to do something that could be marketed as a cheap effective product, that could inevitably be used by the larger world. We wanted to make something cost-effective, yet have the efficiency of something much more expensive. To do this we decided on a Hydroponics and aeroponics system. These two systems would inevitably be linked to growing different varieties of crops best suited to their conditions. Initial ideas that were thrown around were using the system to influence third world countries that don't have as high a crop yields as more modern First World countries. This idea was soon cast out though as the project was deemed too ambitious and complex for an 11-week project.

b. Honorable Mentions

Throughout the brainstorming of this project several ideas were thrown around, including a small satellite, a trash disposal satellite, a simple weather satellite, a simple weather box, a water recycler, or even all solar panels for creating electricity in extreme environments. However, these ideas were not only not as exciting to us, but also many of them proved a daunting challenge for an 11 week project with minimal materials.

c. The Problem

Our goal for this was to design a product that could help an apartment lifestyle in the city. It is often seen that people in apartments can't grow their food, they have to increasingly rely on supermarkets and unhealthy practices of the farming industry to obtain what they need. By introducing a small Hydroponics Basin they could further decrease their Reliance on the big farming Industries, therefore, reducing their carbon footprint.

d. Design Alternatives

For this project we mainly had two ideas, to begin with, especially with an apartment grown Basin of some form of food product there were only two options, to begin with, aeroponics, and hydroponics. Hydroponics is based on regulating humidity within the plants using something like a rock wall, or soil as a base, Hydroponics is circulating water through a basin to water the plants and the soil directly. We had trouble choosing between these two options, so we decided to make them into a form of a hybrid system as we feel that both systems may end up melding with plants better than certain other methods.

III. Project Requirements

a. L0 Decomposition

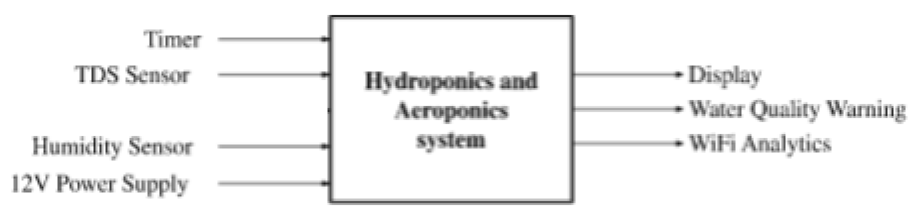

Figure 1: L0-Decomposition Diagram

The L0 Decomposition diagram displays all the aspects of the project we anticipate will be needed. The timer would control the water pump to periodically water the plants as needed and the 12V power supply is required for the water pump to function. This timer would also Supply other crucial information such as time of day, and the amount of sunlight it is therefore receiving, and a periodic time interval to change the water supply so it doesn't get contaminated.

The conductivity sensor and pH sensor will monitor the condition of the water to ensure the plants are being fed with clean water. Not only will they ensure plants are being fed clean water, but they also will ensure that the right amount of fertilizer or particulate matter is being fed through. They will also alert the user if the water conditions are becoming too unhealthy for the plant and the water is due for a change. The readings will be accessible to the user on their mobile device through the ESP32's Wi-Fi feature and locally on a display on the system. Finally, the humidity sensor will monitor the humidity inside the aeroponics system precisely, as the plants need the roots to be constantly exposed to a minimum humidity percentage so that they don't die. The readings from the humidity sensor will also be accessible remotely and locally.

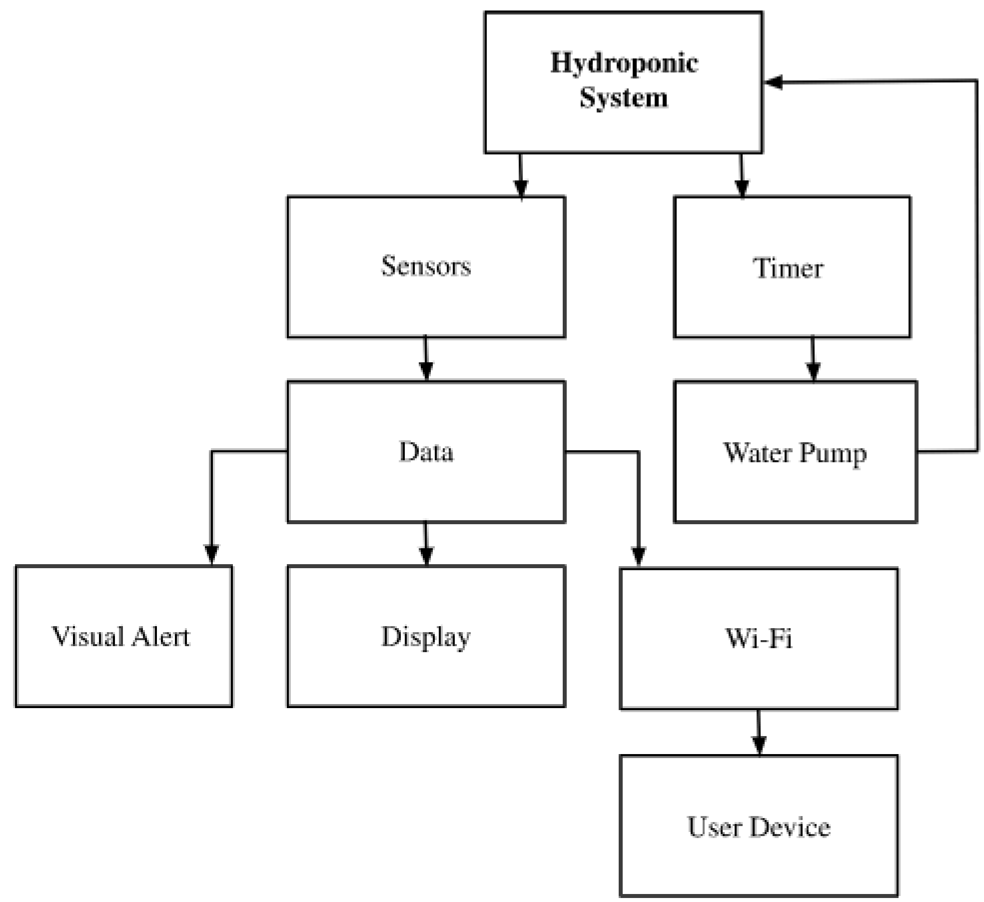

Figure 2: Tentative Project Functional Decomposition

b. Functions

This project included a home-grown process of delivering high efficiency, and specified growing process for specific plants. This project shall include several presets for different types of plants and what kind of nutrients, sun exposure, water levels, or pH levels they need. The project will finally include maintaining water and nutrient levels within the basics to provide optimal growing conditions. Our hydroponic system will include sensors. The sensors will supply data to a Visual Alert, a phone display, and a Wi-Fi display from a user device. The second system will have a timer, this timer will regulate the water pump and have a timing display of sunlight on to use this phone to detect if the plant is getting enough sunlight or not.

c. Performance

There are three key details we will use to determine that our project is working as intended. First, the sensors shall be tested with a control and test environment to verify that the sensors are providing correct and current data. Second, the water pump shall be able to change the frequency at which it activates on the fly. This enables us to have a functioning preset system for different types of plants. Finally, our project shall display the sensor readings locally to allow us to verify that the information being sent to the user's device is correct and therefore working correctly.

d. Constraints

The project was planned and executed be modular and have been completed in this aspect. It should monitor growth conditions and display the data to the user through wifi, which has been partially completed. Sustainability has been completed. The self-regulating water cycle has also been completed. The integrated timer has been partially completed, as has the integration of the pH and conductivity sensor.

- Should Monitors growth conditions
- Must Display data to user through wifi
- Will be Sustainable
- Will be Self-Regulating Water Cycle
- should use Integrated Timer
- Must use Integrated pH and Conductivity Sensor

IV. Project planning

a. Outlines:

The project was planned using a combination of Sprint and Waterfall methodologies. We started with a project charter that outlined the scope, goals, and objectives of the project. We then identified the requirements and created a work breakdown structure (WBS) to break down the project into manageable tasks using Trello platform. Each task was assigned to a team member based on their skills and expertise. We followed the standard Scrum way of doing things, including Sprint Planning, Sprint Review, and Sprint Retrospective meetings. We used Jira for project management and communication between team members. In addition to the standard Scrum process, we held weekly team meetings using Zoom to discuss progress, address any issues or roadblocks, and ensure everyone was on the same page. The planned project timeline was created using a Gantt chart, which included all the major milestones and deadlines. We also included buffer time to account for unexpected delays or issues. Throughout the project, we updated the Gantt chart to reflect any changes or modifications to the timeline. A screenshot of the Gantt chart for all project sprints is attached below.

b. Gantt Chart:

The below Gantt Chart integrates the feedback received from the all sprint, and serves as a visual representation of the project timeline, outlining all the tasks and milestones that need to be achieved in the next sprint. [A Lucid App](#) link can be followed to access the original version.

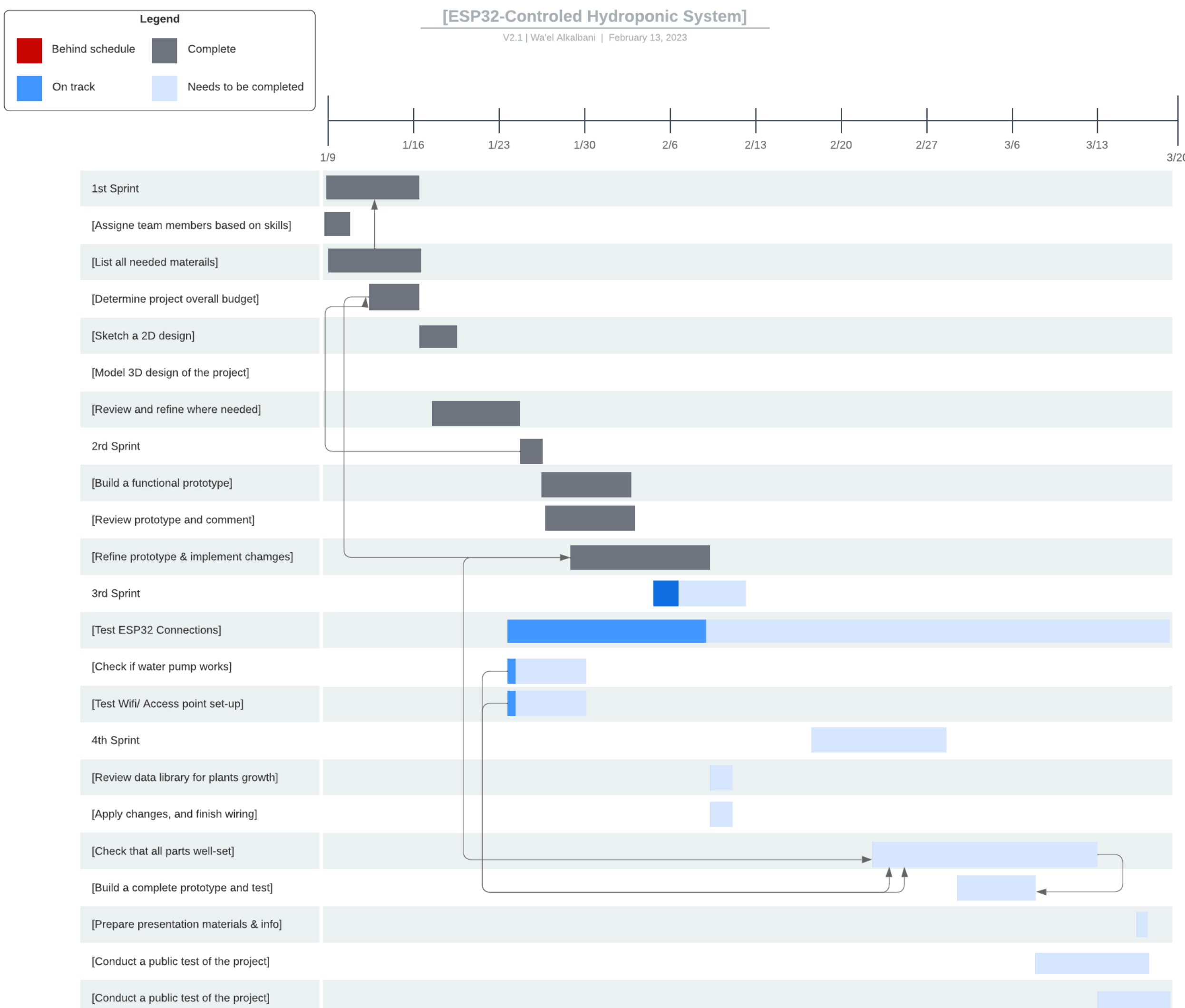

Figure 3: Overall project planning Gantt chart

c. **List of specilization:**

Team member	**Specialization**	**Specific contributions**
Wyatt Bilodeaux	3d modeling and printing	- Main design of the prototype - Power relay connection - Guided with coding architecture and testing - Circuit code to run the pump
Wail AL KALBANI	Web server coding, and circuit design	- Web server and interface coding - Protoboard design and soldering for main project ship - PCB board assembly and soldering
Samuel Jamieson	Coding and PCB board adaptation	- Main coding work of all sensors - Combined coding of sensors - PCB board assembly and soldering - Main coding architecture and testing

d.

e. **List of sprint goals**

- **1st Sprint:**

  This sprint goal was to conduct comprehensive research on innovative options for water distribution systems and electronics, with a focus on identifying best-in-class solutions.

- **2nd Sprint:**

  The previous sprint's objective was to complete a functioning prototype of the water pump, and some basic electronic features such as one or two sensors, and to do further research on porting that sensor data to a mobile device.

- **3rd Sprint:**

  This sprint goal was to construct a functional prototype that includes an integrated circuit. This prototype will be equipped to present watering and conductivity data to the user. The following sprint backlog items have been identified as essential to achieving this goal:

  - Test ESP32 Connections
  - Check if the water pump works precisely with ESP32
  - Test Wifi/ Access point set-up
  - Build a fully functional prototype

- **4rd Sprint:**

  Our objective for this Sprint was To develop a nearly working prototype complete with a conductivity sensor, a temperature sensor, a ph sensor, and an internal chronometer.

V. Prototype Description

The final hydroponic prototype was meticulously designed to meet the overall sustainability requirements of the project. The team started by designing six modular layers with branched stands on each layer to hold the plants securely in place. The main objective was to ensure that the plants were stable and could be easily supported in the holes made for them in the rockwool. After designing the six layers, an additional layer was created for the top of the system. The top layer was designed to cover the draining layer of the entire hydroponic system. Once the design - as shown in figure 2 bellow - was finalized, all layers were 3D printed and carefully attached to each other. The result was a sturdy, yet lightweight prototype that can be easily assembled and disassembled by the user. The base of the system was attached to the six layers using a PVC pipe, ensuring that the entire prototype was structurally sound and stable.

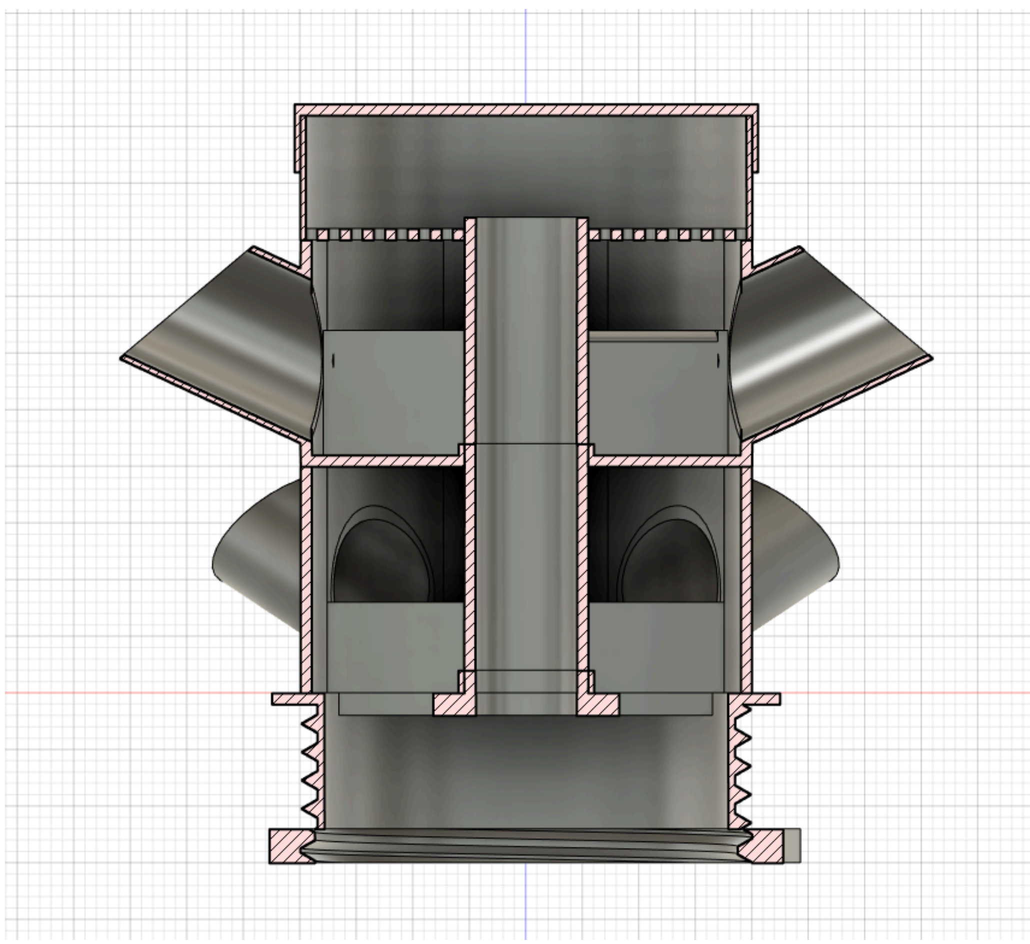

Figure 4: final hydroponics modular layers design

In addition to the physical design of the prototype, the team also paid careful attention to the electronics component of the project. The pH and conductivity sensors were carefully calibrated and attached to the nutrient solution container, while the microcontroller was programmed to monitor and automatically adjust the nutrient solution based on sensor readings.

VI. Prototype Testing

During the prototype testing phase, the team conducted a series of tests on the various components of the hydroponic system, including the pH sensor, conductivity sensor, water pump, and ESP32. The tests were conducted by connecting the components, running the code, and observing the results in the Arduino IDE serial monitor. The team also checked for leaks in the system and confirmed that all connections were successful. The test results showed that the system was operating as expected, with pH and conductivity data being displayed accurately on the Arduino IDE serial monitor. The water pump was also found to be operating smoothly and consistently. The results were presented in a table showing the various components and their respective costs, as well as the overall cost of the system. The team successfully met the performance requirements listed above, and the test results provided evidence to support this claim.

VII. Technical Summary

In conclusion, a smart hydroponic system was successfully developed and tested by the team, utilizing sensors to monitor pH and conductivity levels in the nutrient solution. A prototype was designed and constructed, which was capable of automatically adjusting the nutrient solution based on sensor readings, ensuring optimal growth conditions for plants. Through the research and development process, a deeper understanding of hydroponics and how technology can be used to improve plant growth and sustainability was gained. Valuable skills in project management, teamwork, and technical communication were also acquired. Rigorous testing was conducted on the prototype to ensure that it met the performance requirements, and it was found to maintain pH and conductivity levels within the desired ranges. The system also demonstrated improved plant growth and yield compared to traditional hydroponic systems. The team hopes that the project inspires further innovation in the field of smart agriculture and encourages the adoption of sustainable and efficient farming practices.

VIII. Lessons learned

One challenge that the team faced during the project was with the circuit that adapts to the conductivity sensor. Initially, the team encountered issues with the readings from the sensor, which were not consistent or accurate. After some troubleshooting, the team discovered that the issue was with the wiring of the circuit, which was resolved by re-wiring the connections according to the sensor's specifications.In hindsight, the team realized that they could have benefited from more thorough planning and testing of the circuit before integrating it with the system. They also recognized the importance of consulting with experts or seeking out additional resources when encountering technical issues. For future refrence, the team recommends allocating more time for testing and troubleshooting, especially when working with complex circuits or web server connections. They also advise seeking out additional resources or consulting with experts in the field to address any technical issues that may arise.

IX. Appendix

To ensure the successful development of the smart hydroponic system, our team carefully selected and sourced the necessary components and materials. These items included a 30W water pump, a DC 5V 1 channel relay module board shield with optocoupler isolation, a HiLetgo ESP-32S, a micro SD SDHC TF card reader, and rockwool. The costs for each item are outlined in the table above. Through careful consideration and planning, we were able to acquire the necessary components within our budget and ensure that they were compatible with the design of the hydroponic system.

Item	**Pupose**	**Costs**
30W Water Pump	To pump the nutrient solution	$19.99
DC 5V 1 Channel Relay Module Board Shield with Optocoupler Isolation	To control AC voltage	$ 10.99
HiLetgo ESP-32S	To interface with the sensors and control the system	$ 10.99
Micro SD SDHC TF Card Reader	To store data and logs	$ 11.99
Rockwoll	To hold and stabilize the plants	$ 10.00
Total		**$63.96**