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Engineering

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Project Group ID - 11

Hydroponics Based Precision Farming With Feature Optimization

Names of the students

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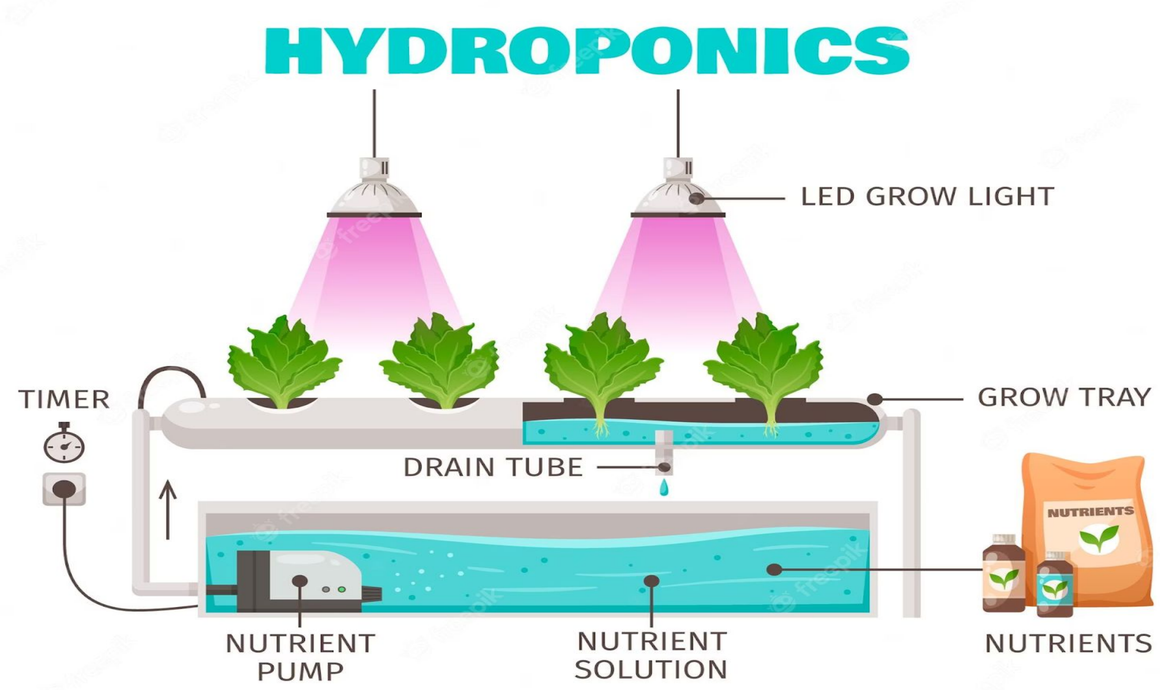
Overview :

1.1. What is hydroponics?

- Hydroponics is a modern agricultural method that involves **growing plants without soil,** using nutrient-rich water solutions to supply essential minerals directly to the plant roots.

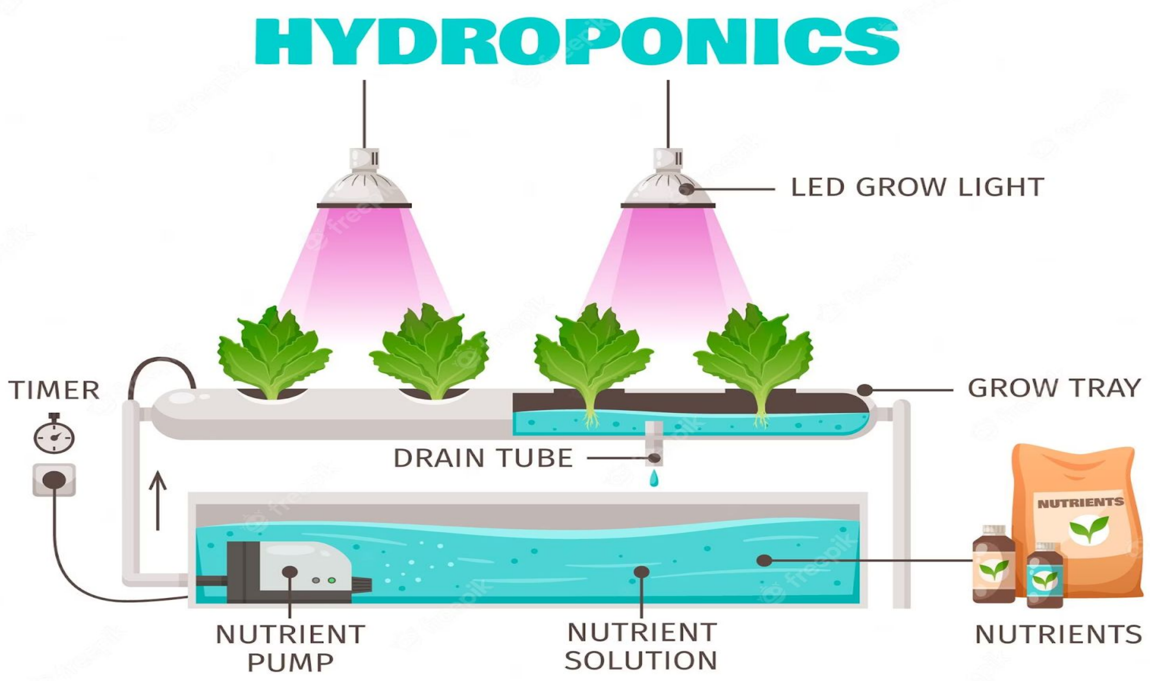
- In hydroponic systems, plants are typically **grown in a controlled environment,** such as greenhouses or indoor setups, where factors like temperature, light, and humidity can be carefully regulated to maximize plant growth and productivity.



1.2. Advantages of Hydroponics over Soil Farming

- Hydroponics allows for **efficient water recycling and requires less water** compared to traditional soil-based farming, promoting sustainable water management in agriculture.

- With hydroponics, growers have **precise control over nutrient supply**, ensuring plants receive the exact nutrients they need, leading to optimized growth and higher yields.

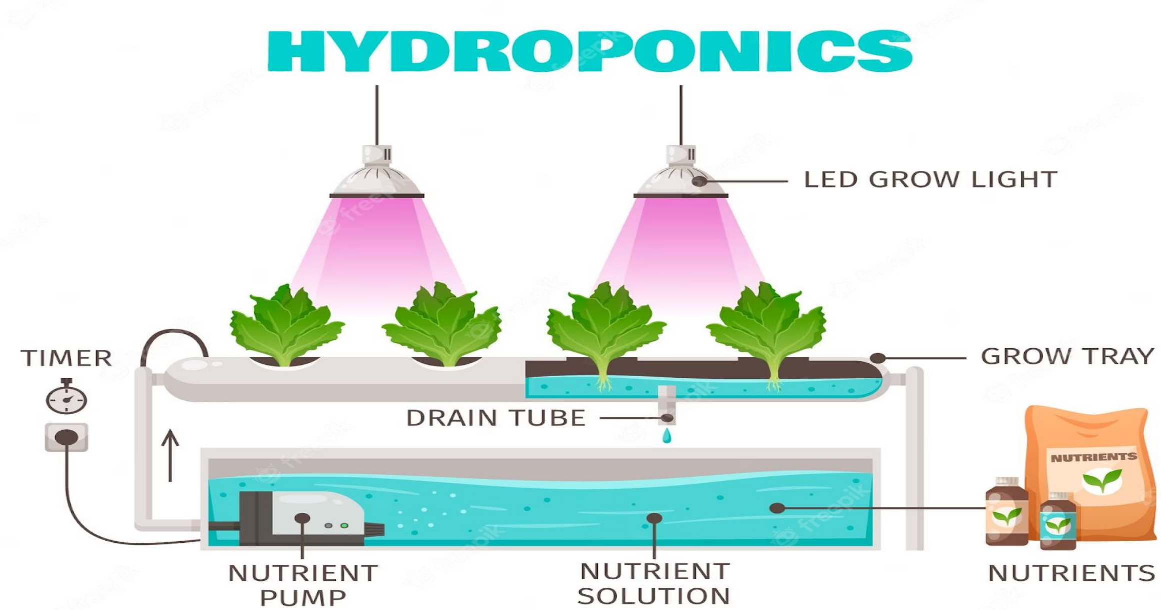


1.3. Current Limitations with Hydroponics

- The **initial setup cost** of hydroponic systems can be relatively high, including investments in equipment, infrastructure, and technology, making it less accessible for small-scale farmers.

- **Inadequate monitoring of air supply** in closed hydroponic environments may lead to oxygen deficiencies, affecting root health and ultimately causing plant mortality.

- Hydroponic farming demands a **deeper understanding of nutrient management, and system operation**, requiring farmers to possess specialized knowledge and expertise, which may be a barrier for newcomers to the technique.



2. Literature Survey

2.1. Research literature survey summary

- New technologies are being researched and improvements are being done in areas like nutrients composition, supply, medium as well as effect of light, temperature, humidity and EC/TDS and pH conditions as this have show to have a linear relation with plant growth.

- Althogt introduction of automation and and AI in hydroponics has been stated for a long long time, most of it has been for simulated environment, either physical or virtual through matlab.

- Even model building of Ai research work exists most of them are either for simulated environment, and built using data form real, life but their effectiveness in actual farming has not been shown.

- As most work in his domain have not utilised/shown research techniques that will turn this technology(introction of ai and automation) into a feasible product , showing efficiency, and effectivity which we intend to do rather than only focuning of plant growth.

2.2. Market literature survey summary

1. The Hydroponics Market size is expected to grow from USD 4.69 billion in 2023 to USD 6.83 billion by 2028, at a CAGR of 7.80% during the forecast period (2023-2028).North America Dominates the Market, while asia pacific is fastest growing in market [1].

1. It is set to grow rapidly on account of the surging implementation of this agricultural method in Australia, Japan, India, and China [2].

1. The global market is highly fragmented with the presence of multiple companies. Most of them are focusing on R&D activities to come up with state-of-the-art techniques for surging sustainability and saving costs [3].

1. March 2021: The state government of Ahmedabad announced its plan to accelerate hydroponic farming in cities to encourage households to grow vegetables in their homes. The agriculture department staff will provide hands-on training to residents with DIY videos [4].

3. Methodology

- **Conduct research on optimizing** the effects of TDS, air pump duration UV light duration on plant growth with various control scheme as per given data with appropriate algorithms.

- **Predict water** tank **refill** time using humidity and temperature with given data with appropriate algorithms.

- Design air pump, water pump, fan **driver circuits** for effective and safe use of electronics resources.

- Implement the LDR sensor for **fault detection** of UV lights**.**

- Incorporate **Sensors and Actuators** to automate the watering process if sensors value falls below a predetermined threshold.

- Incorporate **schedule operations,** allowing for continued functionality even after lights shut down.

- Implementation of **Image processing and analysis** to support monitoring of Plant growth.

- Integration of **cloud and Iot technology** for data processing and enabling for future advancements.

- Use of **M2M techniques** for efficient data flow of system.

- UPS using **mosfet as a diode controlled device** and NOT logic.

4. Specification

4.1 Sensor Module Input Specifications

Parameter	Description
Power Supply Voltage	5V
Communication	WiFi connectivity
Temperature Range	0°C to 50°C (DHT11 sensor)
Humidity Range	20% to 90% RH (DHT11 sensor)
Light Detection	Analog Voltage Output (LDR)
Water Level Depth	Analog Voltage Output (Water level sensor)

4.2 General Specifications of Sensor Module

Parameter	Description
Microcontroller	Wemos D1 mini
Temperature/ Humidity Sensor	DHT11
Light Sensor	LDR (Light Dependent Resistor)
Water Level Sensor	Analog Water Level Sensor
Communication Protocol	WiFi (802.11 b/g/n)
Operating Voltage	5V
Dimensions	7 cm x 8 cm x 2.5 cm
Operating Temperature	-40°C to 85°C

4.3 Sensor Module Features

- Monitors temperature and humidity using DHT11 sensor.
- Detects light status using an LDR (Light Dependent Resistor).
- Monitors water level depth using a water level sensor.
- Integrates Wemos D1 mini microcontroller for WiFi connectivity.
- Sends data to the cloud through WiFi.

4. Specification

4.4 Actuator Module Output Specifications

Parameter	Description
LED Voltage	Collector Current: 50 mA, C-E Voltage: max. 35V
Motor Voltage	Up to 5V, Peak Output Current: 600mA, Continuous Output Current: 200mA
Motor Control	Speed control (adjustable PWM)

4.5 General Specifications of the Actuators

Parameter	Description
Microcontroller	Wemos D1 mini
Optocoupler	PC817
Motor Driver	L293D
Communication Protocol	WiFi (802.11 b/g/n)
Operating Voltage	5V
Dimensions	7cm x 8cm x 2.5cm
Operating Temperature	-40°C to 85°C

4.6 Actuator Module Features

- Operates LED violet light using 2 PC817 optoisolators.
- Controls up to 4 motors with adjustable speed using 2 L293D motor drivers.
- Integrates Wemos D1 mini microcontroller for WiFi connectivity.
- Allows system operation through web and app interfaces.
- Operates on 5V power supply.

4. Specification

4.7 External system specification

4.7.1 LED Violet light

- Type: USB
- Adjustable intensity
- Adjustable color (red, blue, violet)
- Voltage at Max. Brightness: 5V, DC
- Current at Max. Brightness: 1.45A

4.7.2 Air pump

- Type: USB
- Voltage consumption: 5 – 5.1V, DC
- Current consumption: 0.15A

4.7.3 Fan

- Type: USB
- Voltage consumption at maximum speed: 5V, DC
- Current consumption at maximum speed: 0.91A

4.7.4 Water pump

- Voltage consumption: 5V
- Current consumption: 0.31A

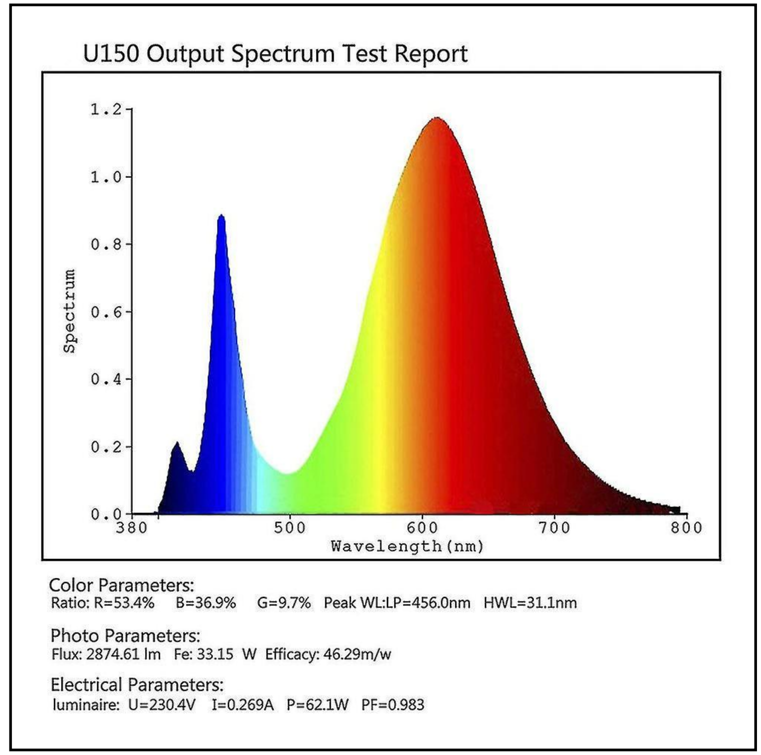
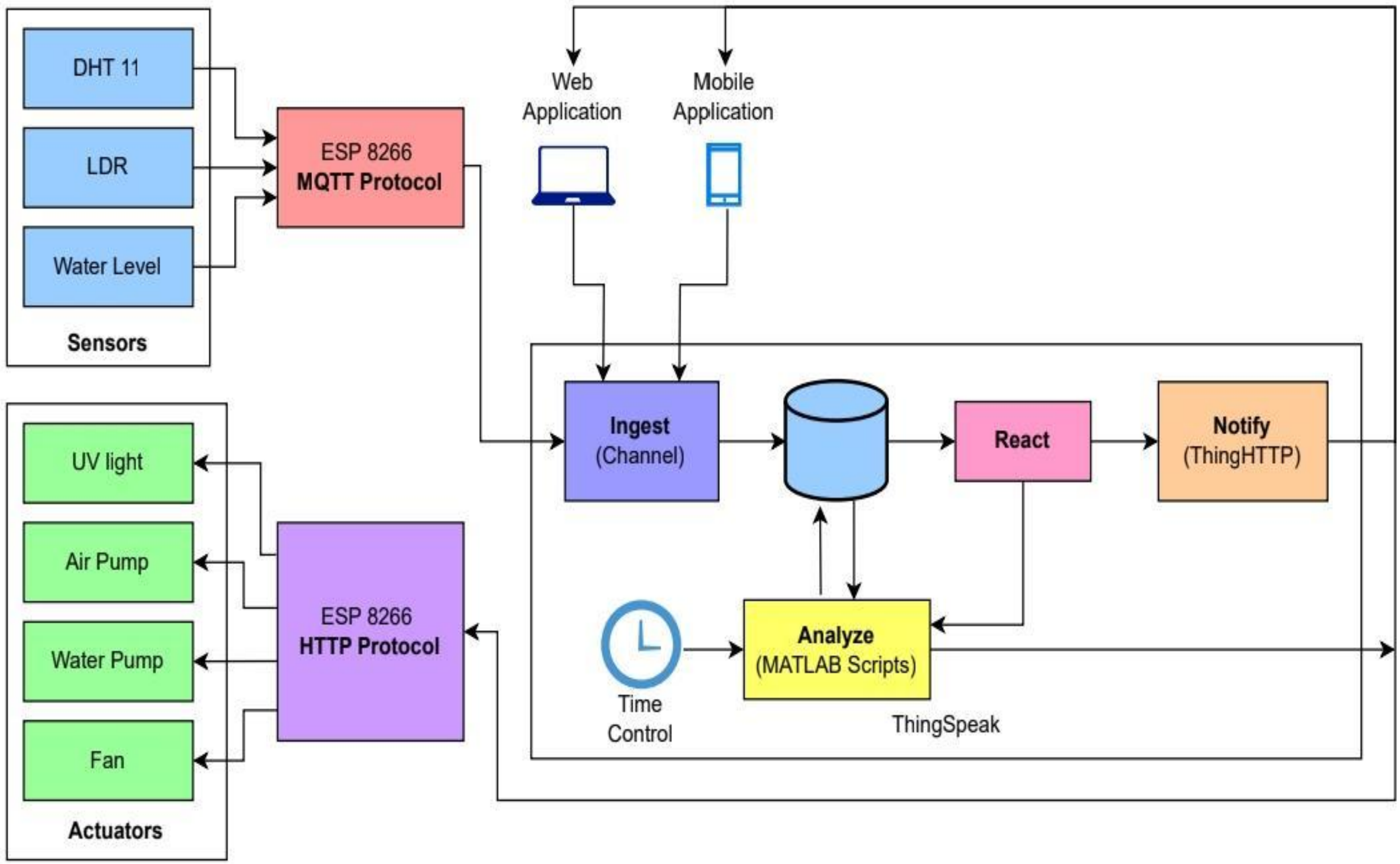


Fig. 3.4: LED Violet Light Spectrum

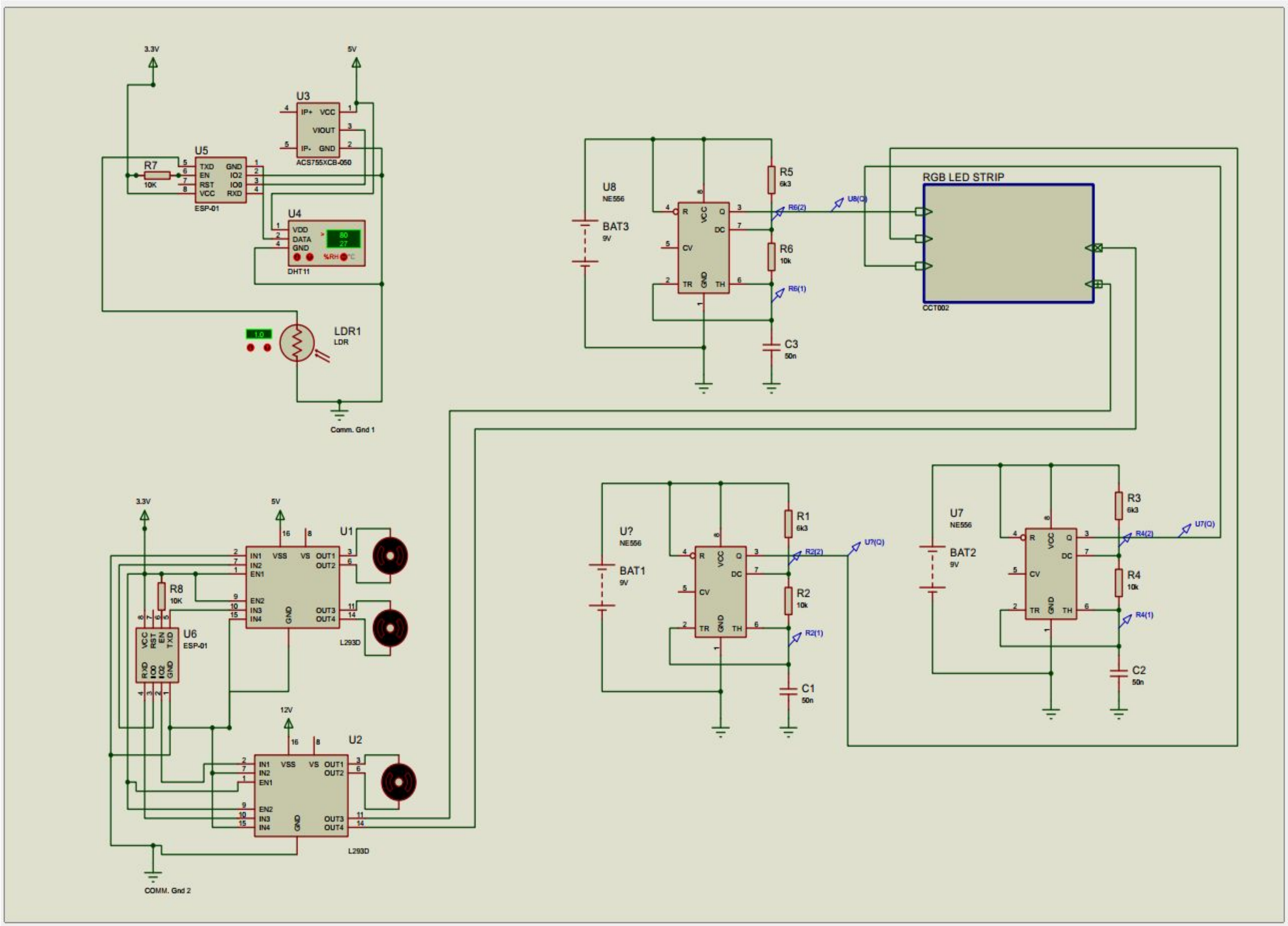
Source: https://www.amazon.com/dp/B07312WKX2

5. Block Diagram



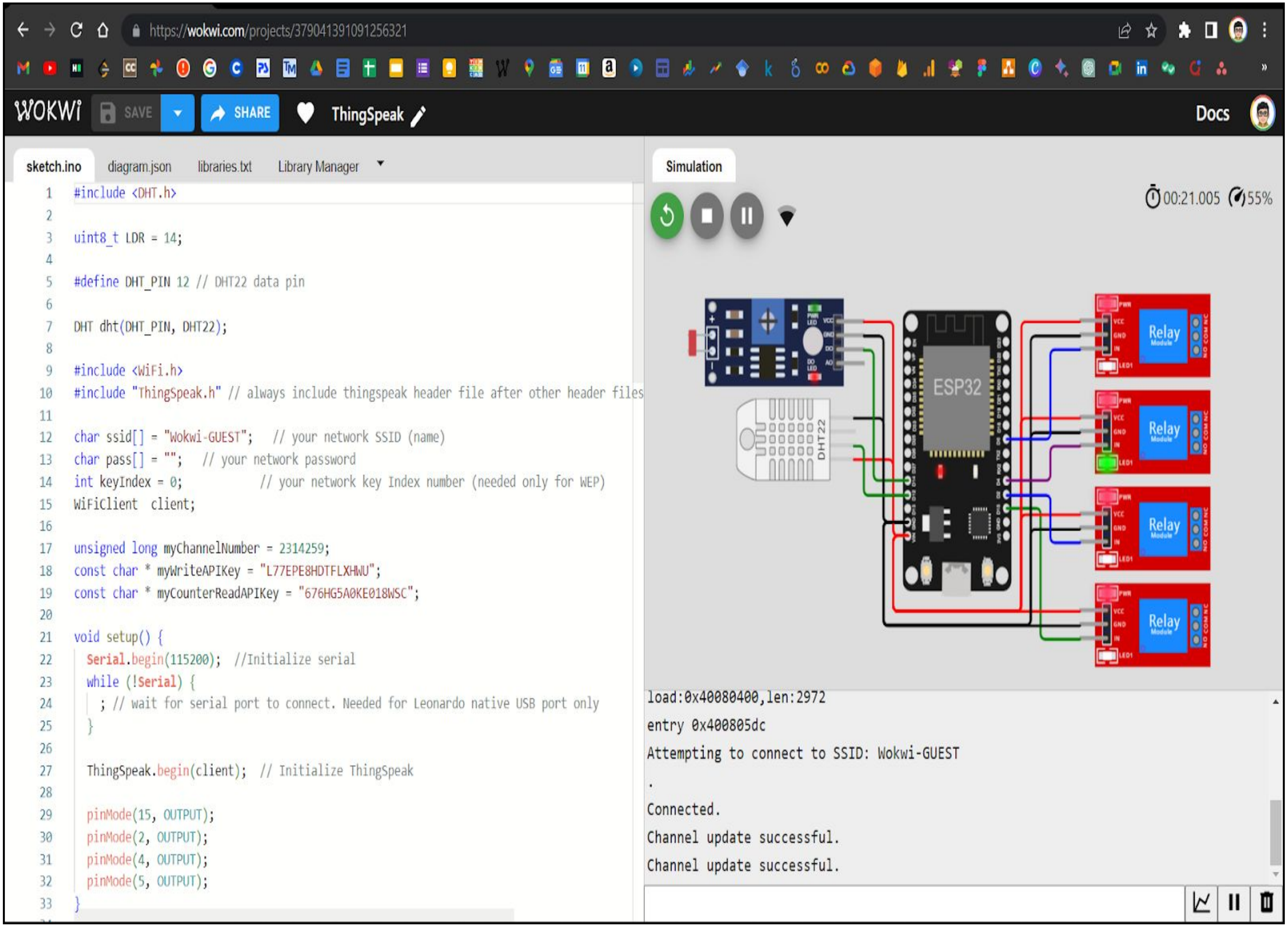
6. Hardware Design

6.1. Schematic

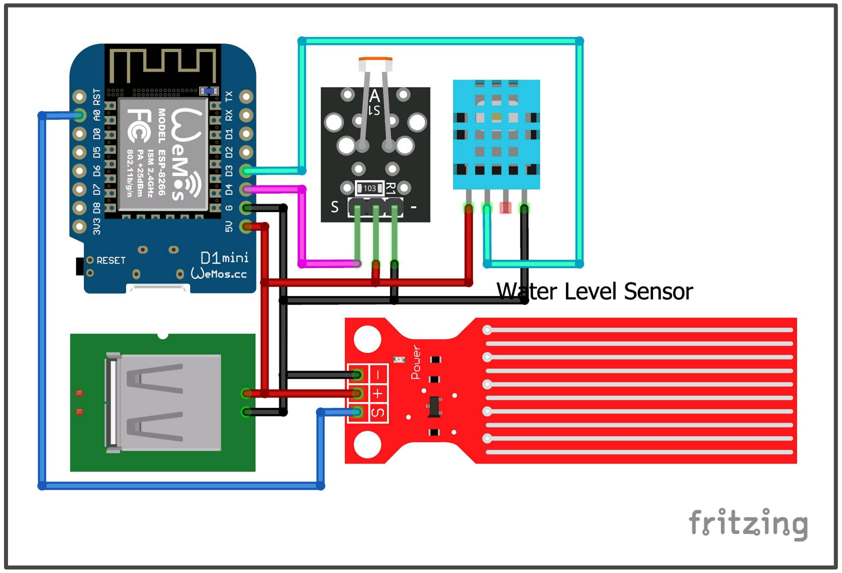


6. Hardware Design

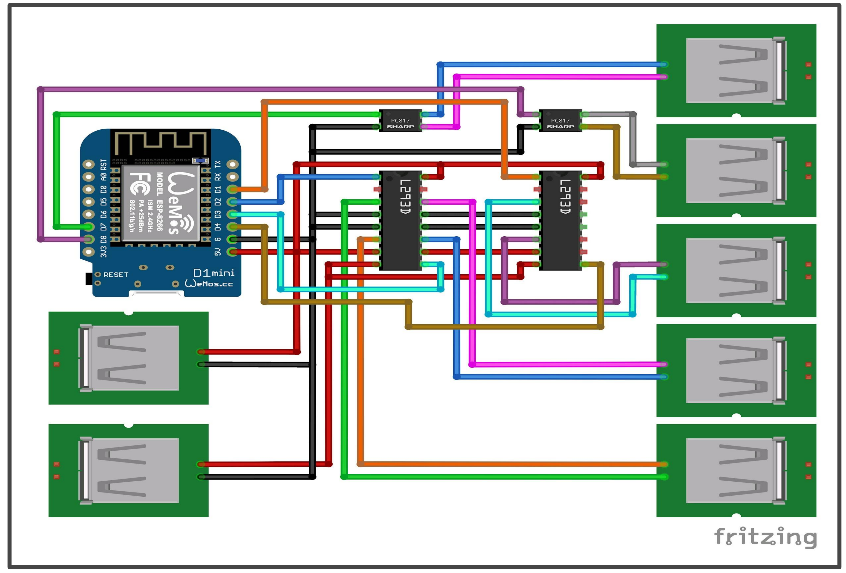
6.2. Simulation Done on Wokwi



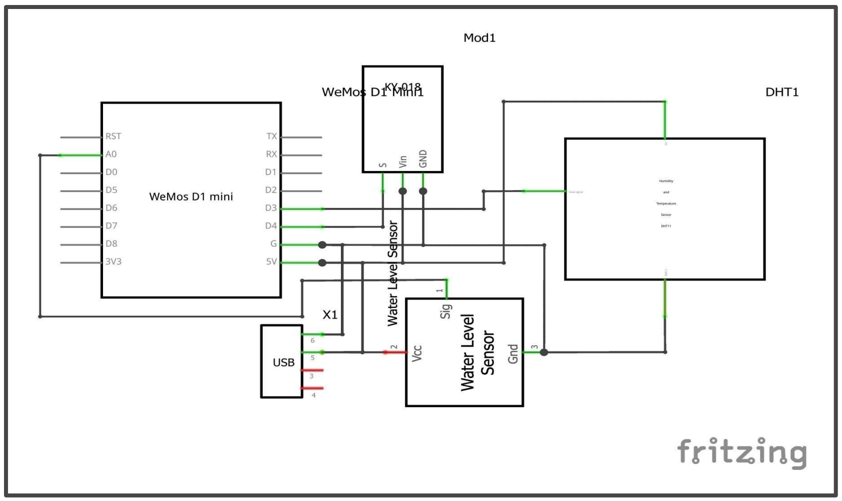
6. Hardware Design



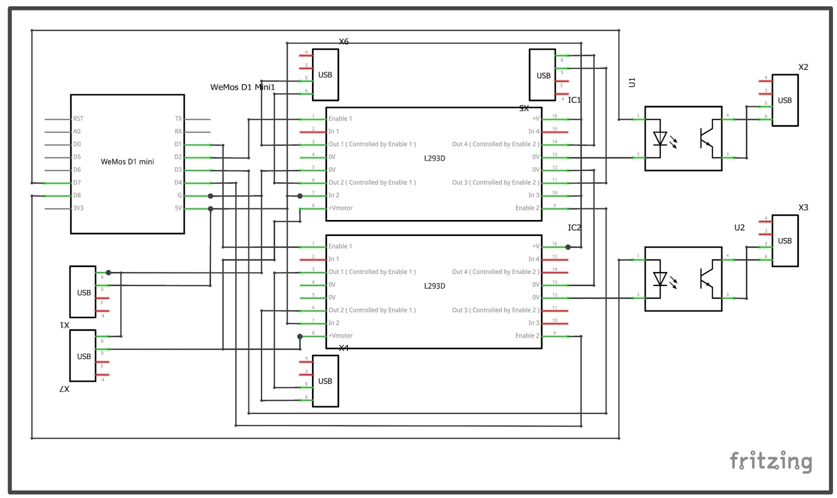
6.3. Breadboard Circuit Diagram of the Sensor Module.



6.4. Breadboard Circuit Diagram of the Actuator Module.

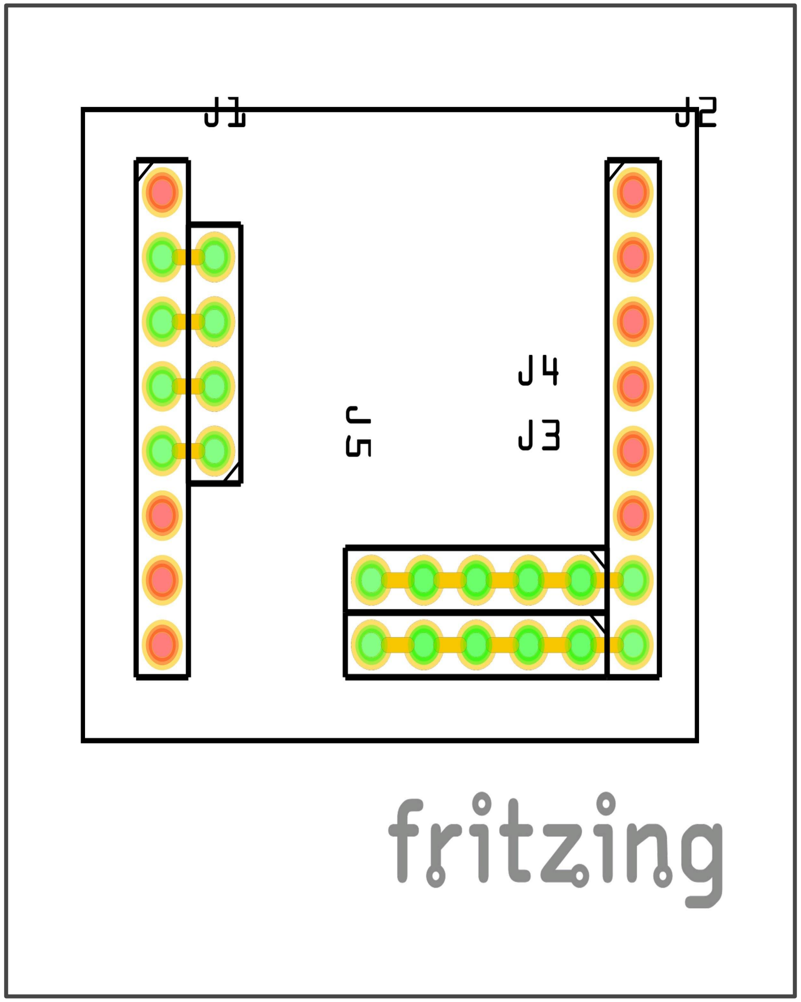


6.5. Schematic Diagram of Sensor Module.

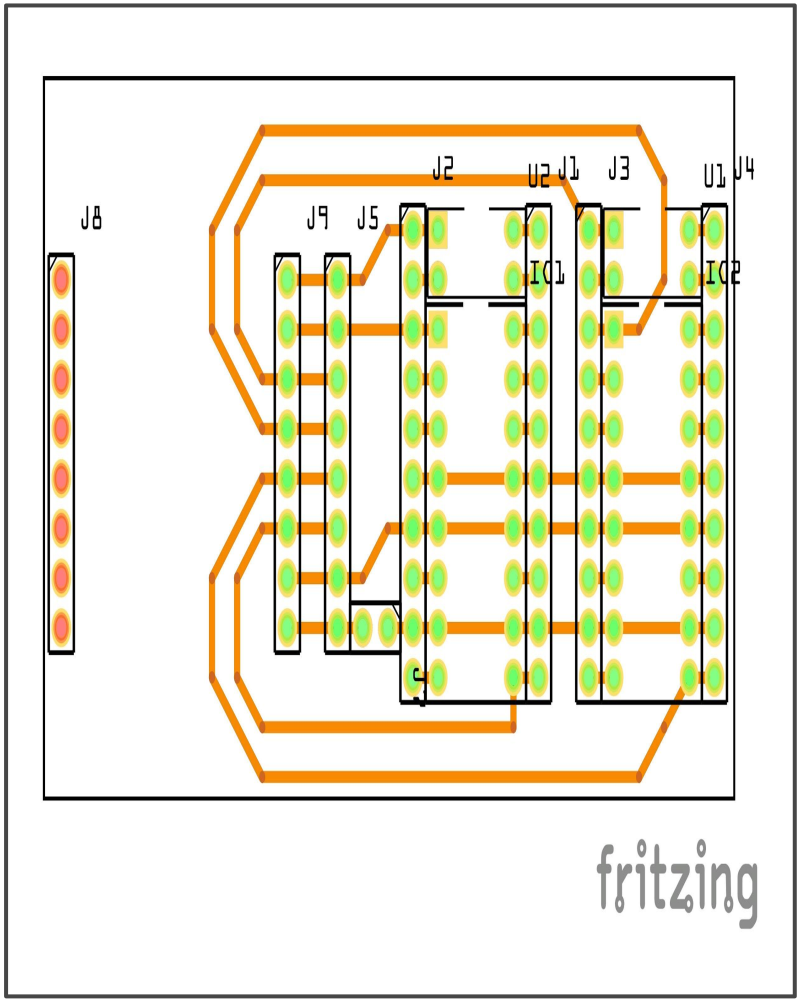


6.6. Schematic Diagram of Actuator Module.

6. Hardware Design

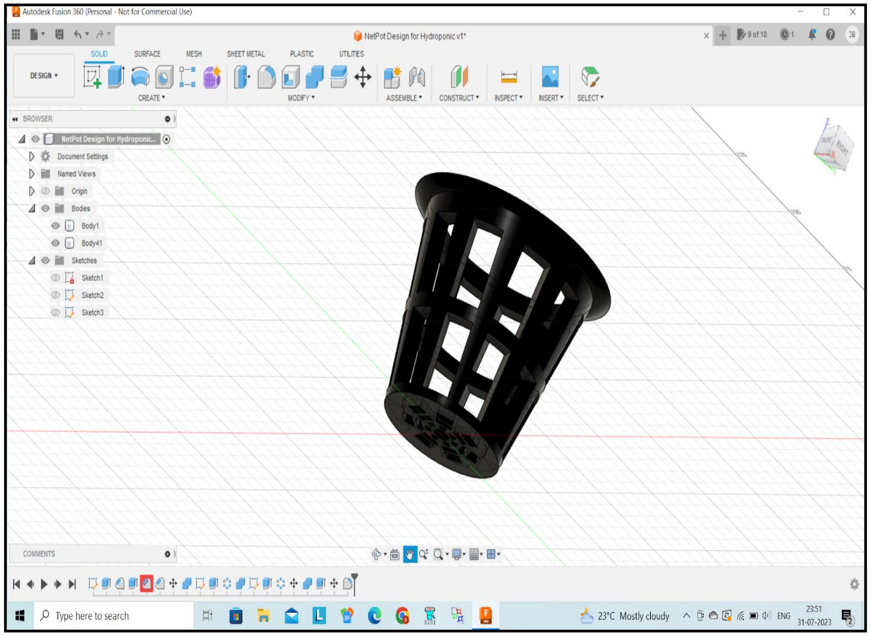


6.7. PCB Designing of Sensor Module

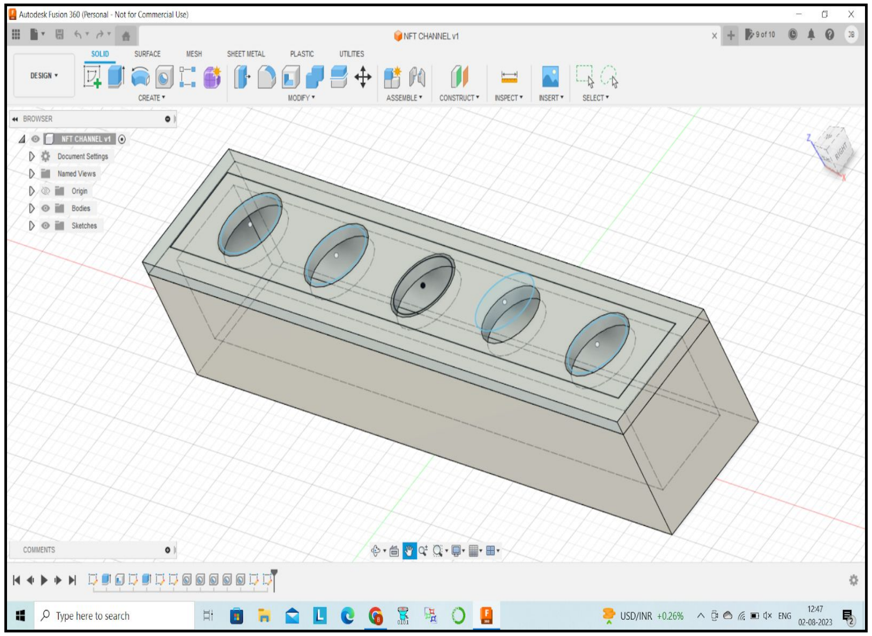


6.8. PCB Designing of Actuator Module

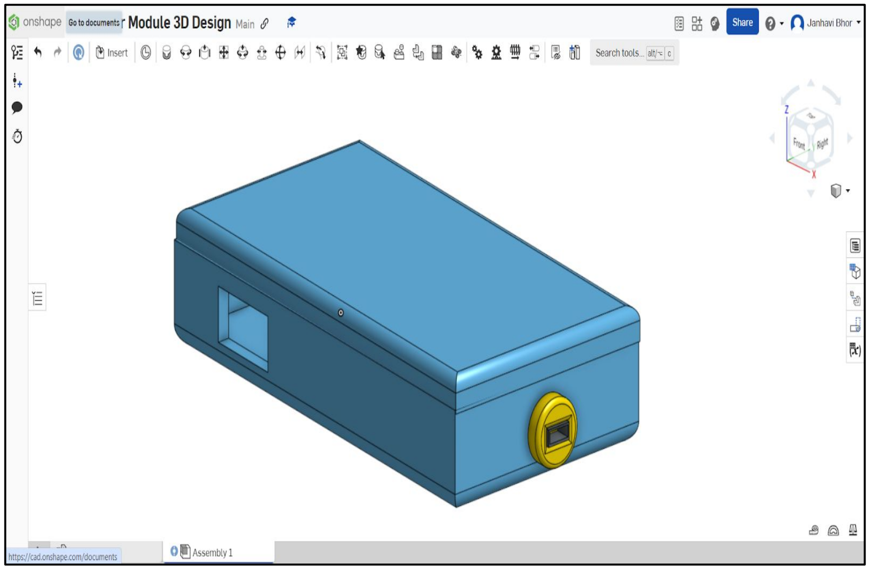
6. Hardware Design



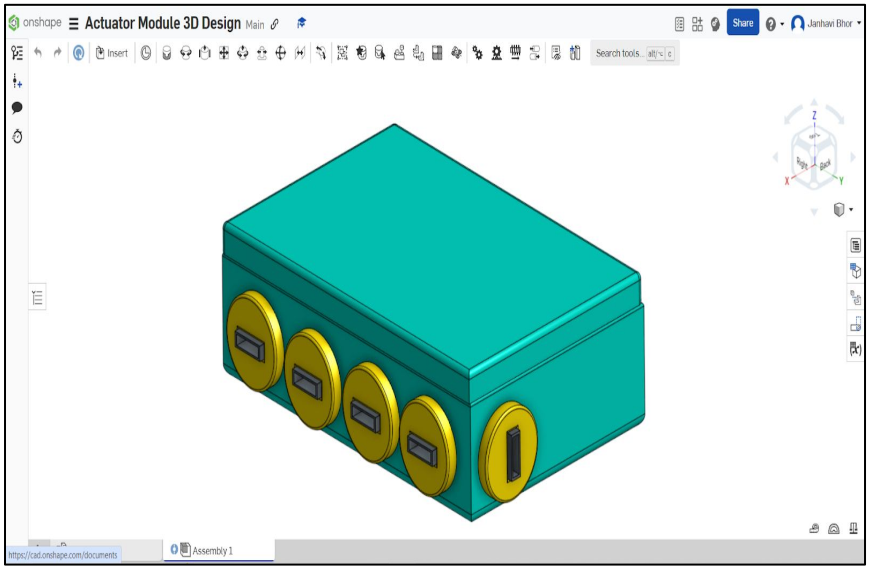
6.9 : Enclosure design for NetPot on fusion 360



6.10 : Enclosure design for NFT Channel on fusion 360

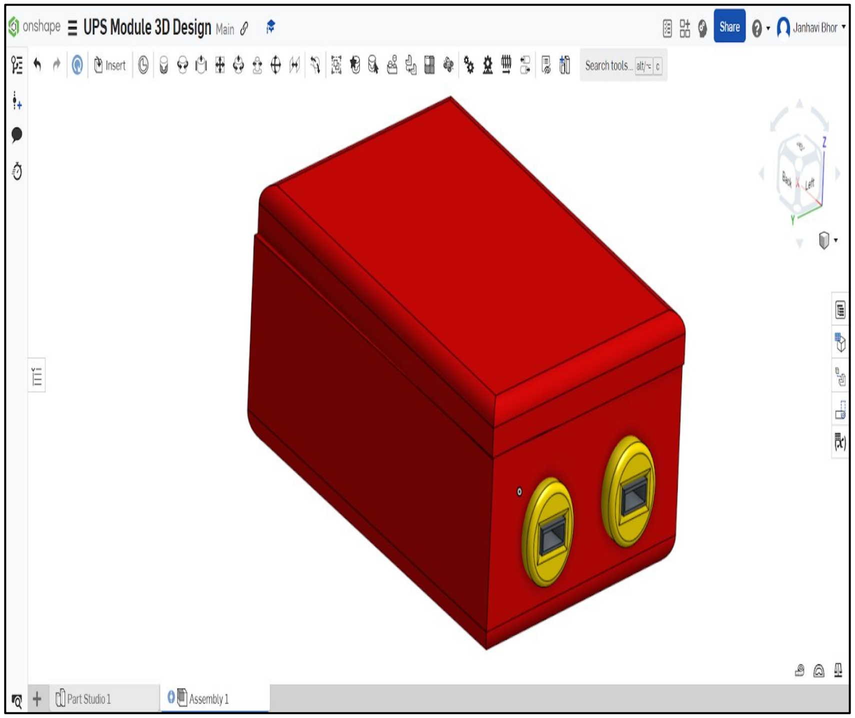


6.11 : Enclosure design for Sensor Module on OnShape

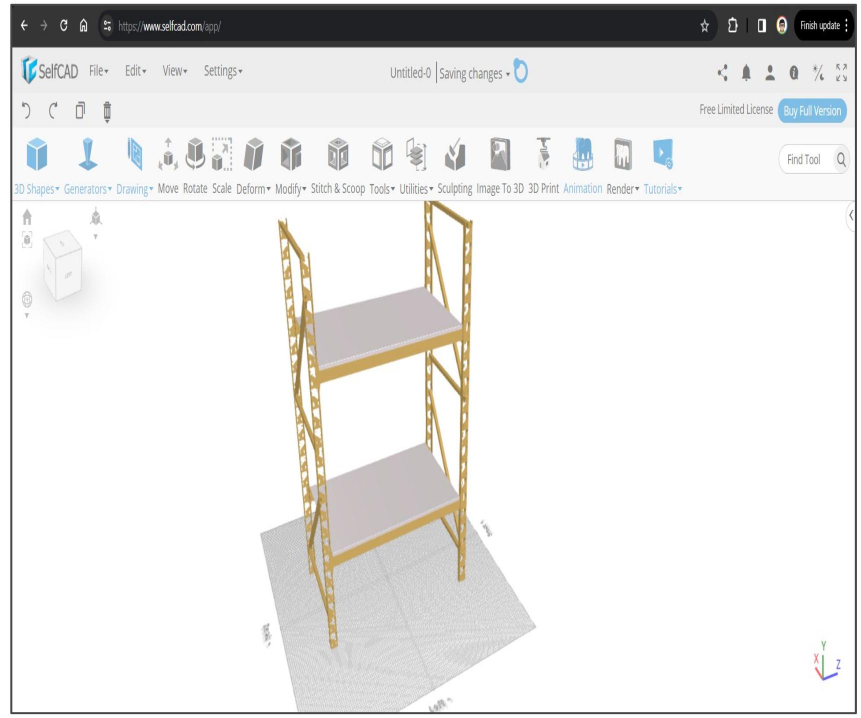


6.12 : Enclosure design for Actuator Module on OnShape

6. Hardware Design



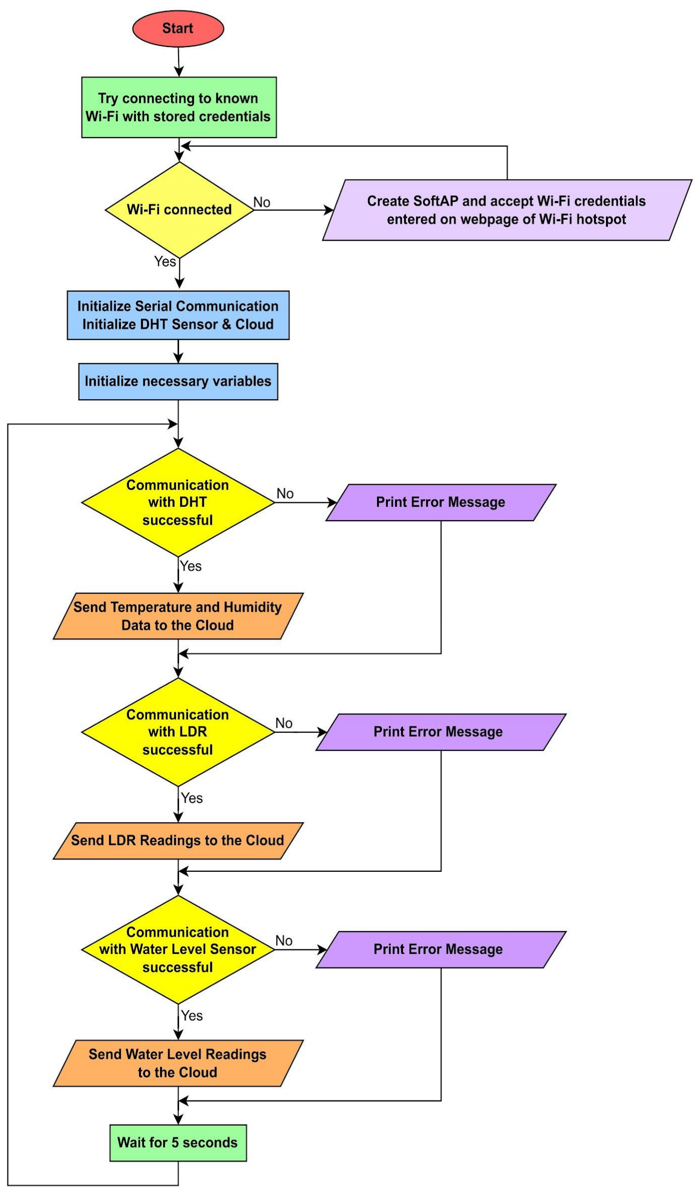
6.13 : Enclosure design for UPS Module on OnShape



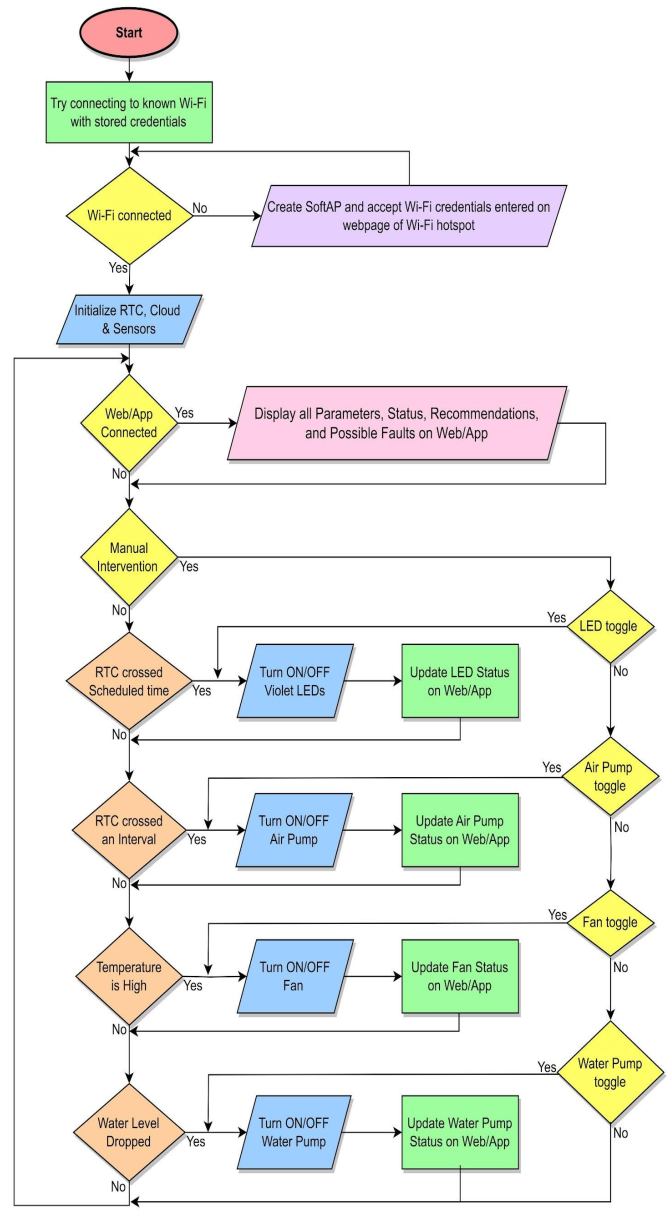
6.14 : Enclosure design for Stack on SelfCAD

7. Software Design

7.1. Flowchart of the Sensor module

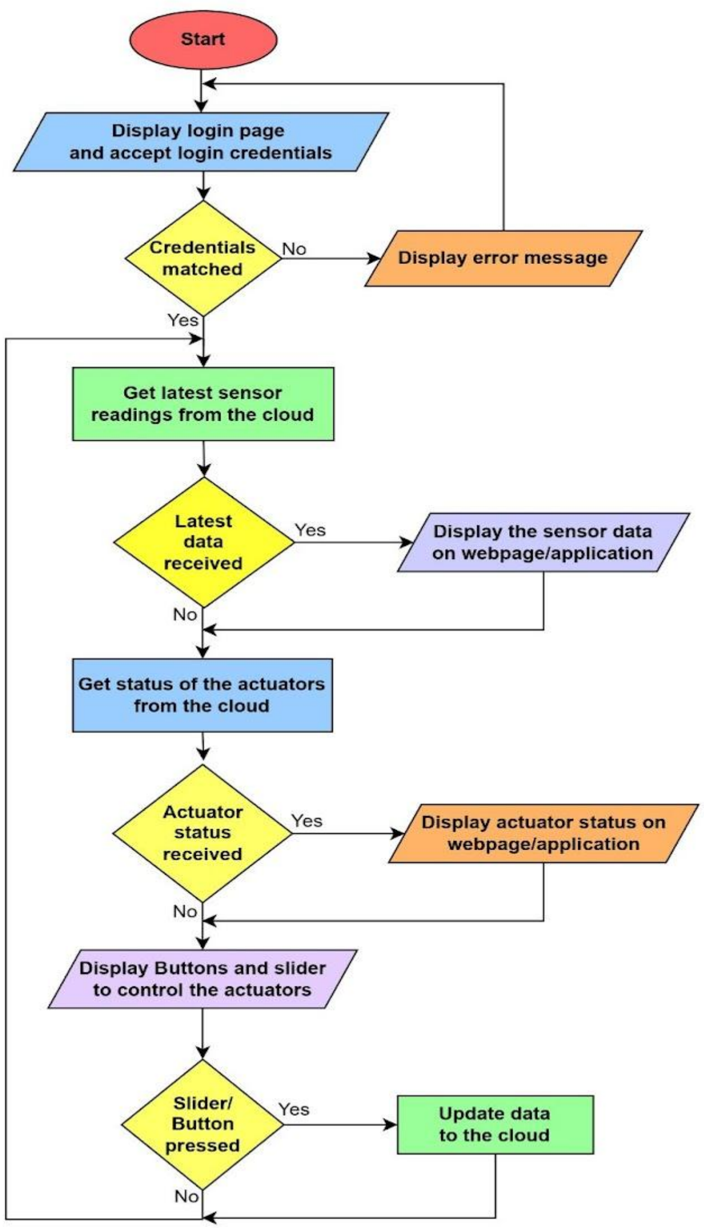


7.2. Flowchart of the Actuator Module

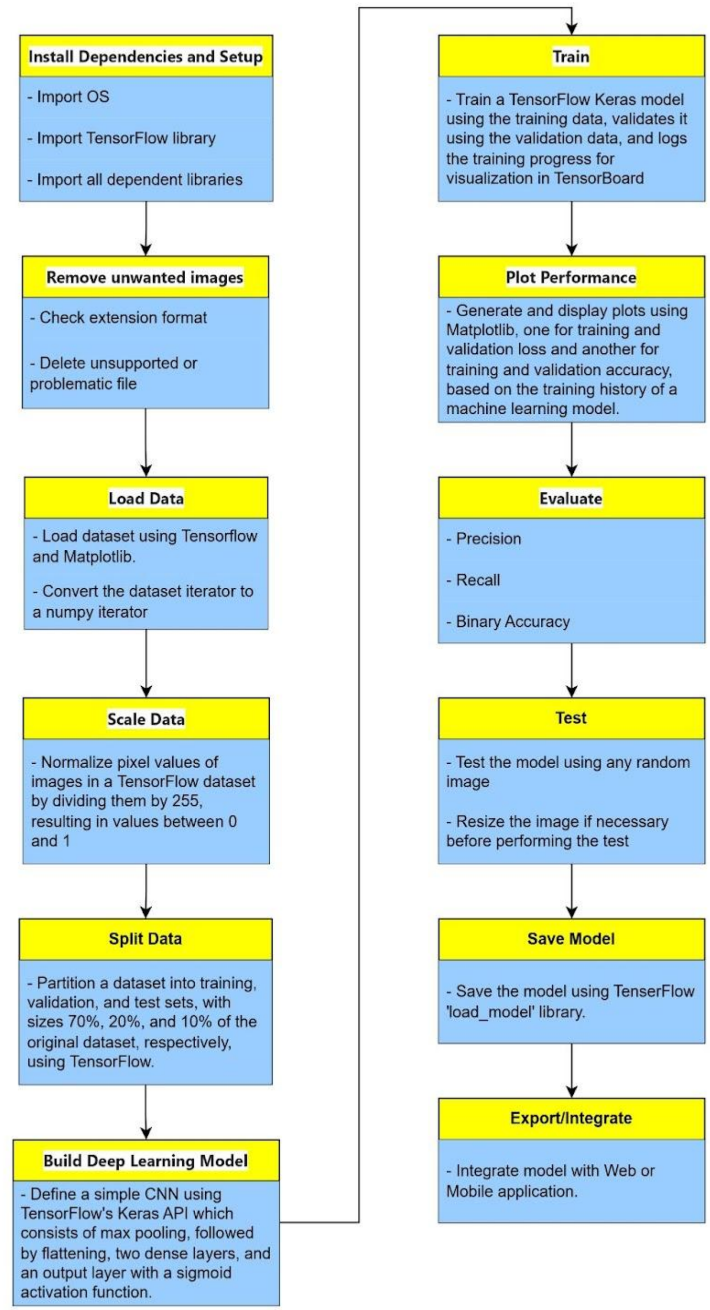


7. Software Design

7.3. Flowchart of the Webpage/Application



7.4. Steps to Train AI with Images



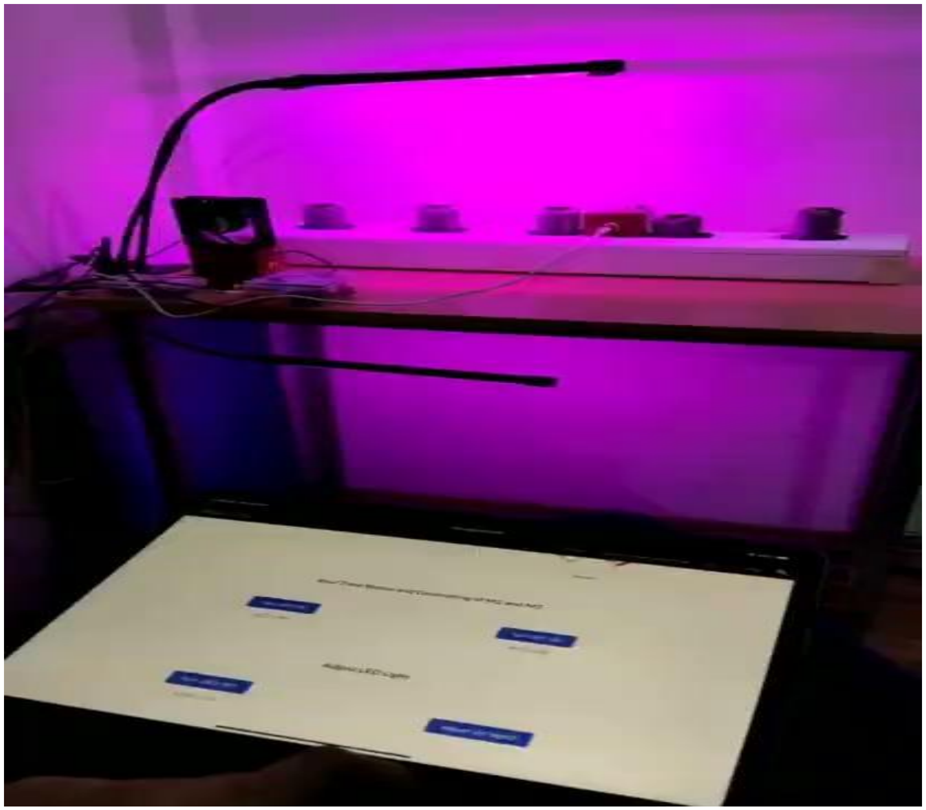
8. Result

8.1. Final Setup

Fig 3.1. Final Setup with Lights OFF

Fig 3.2. Final Setup with Lights ON

8.2. Video of Changing UV Light



Video of Adjusting the UV Light

Video of Turning UV Light ON & OFF

8.3. Wi-Fi Credentials Change

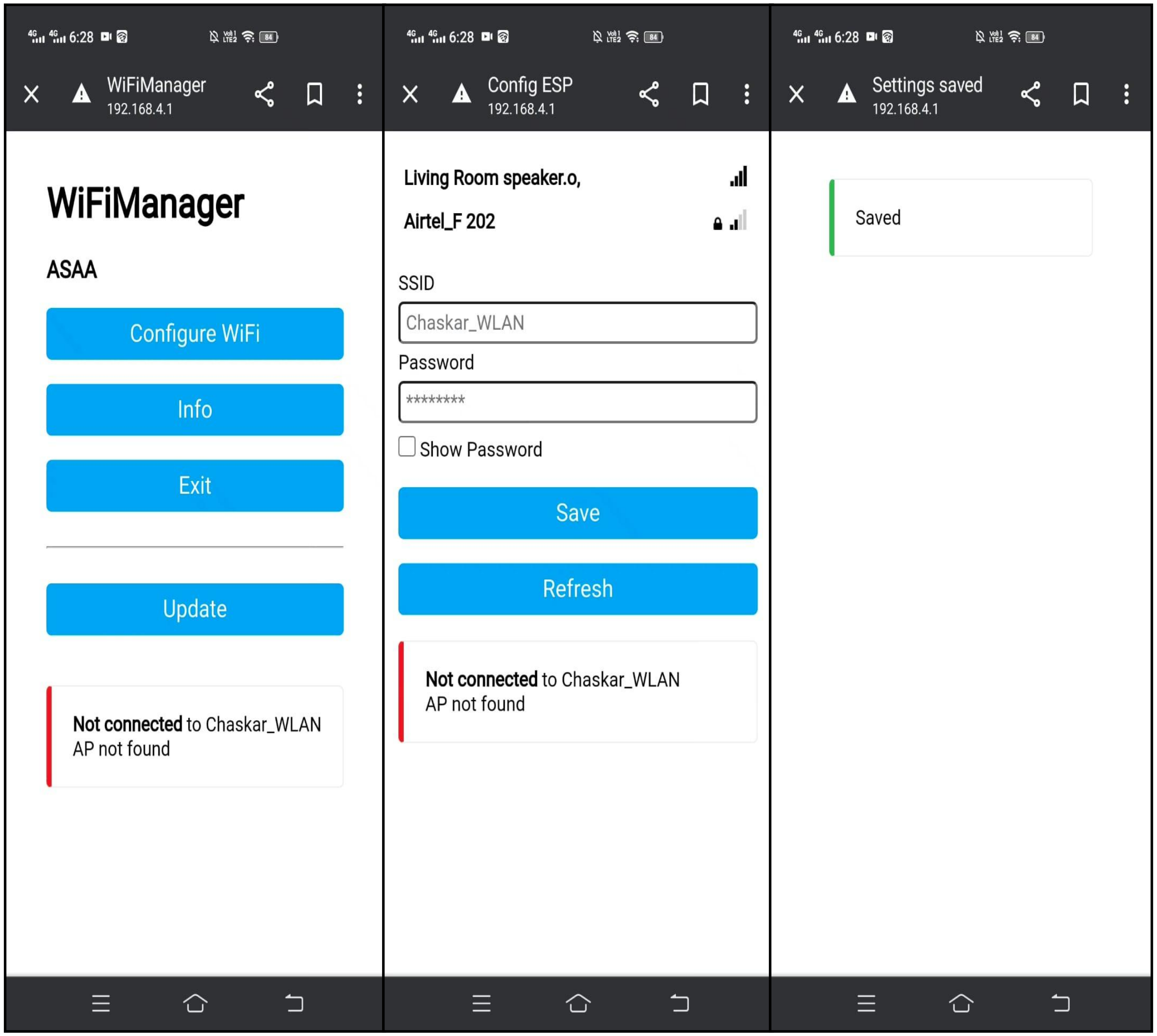
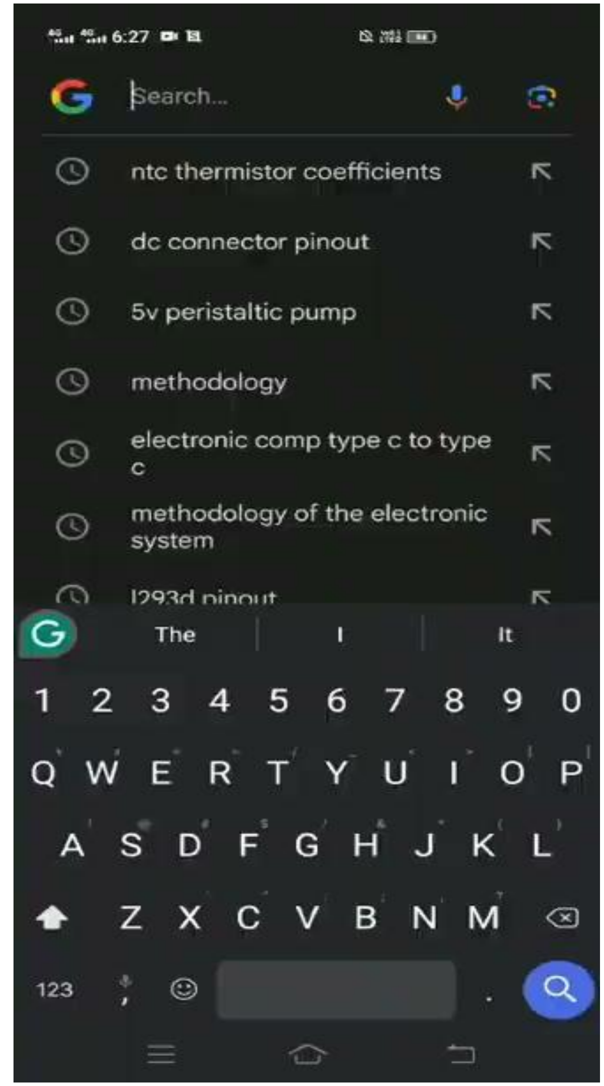


Fig 8.3. Screenshots taken while changing the Wi-Fi credentials



Video of Changing Wi-Fi Credentials

8.4. Plants grown using our setup

Fig 8.4.1. Chickpea Plant

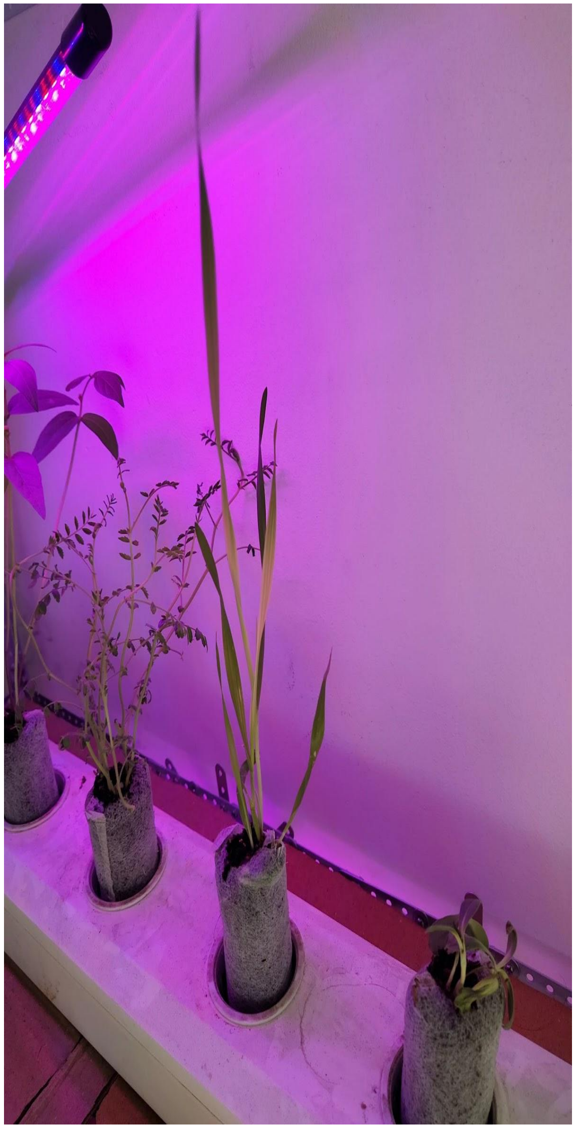


Fig 8.4.2. Wheat Plant

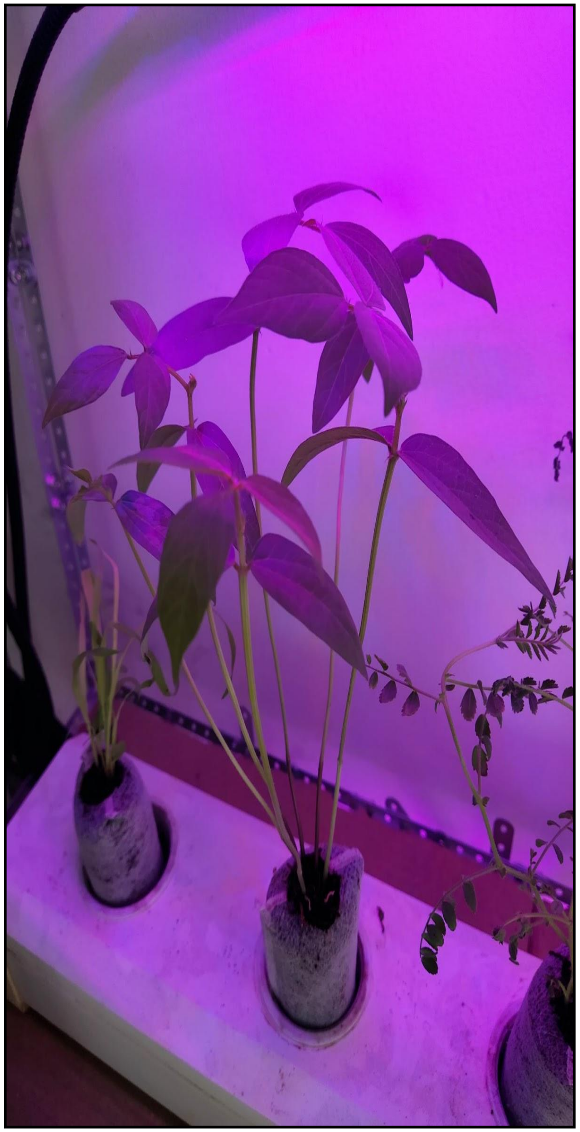


Fig 8.4.3. Mung Bean Plant

9. Conclusion

1. Hydroponic precision farming saves space by eliminating the need for large land areas, making it perfect for urban areas with limited space.

2. Precise control of temperature, light, and water levels leads to higher yields and healthier crops.

3. Automation reduces human error, ensuring consistent production to the highest standards.

4. It enables 30-50% faster growth and reduces water consumption by 70-85% compared to soil-based farming.

5. The system operates autonomously, minimizing the need for human intervention and labor costs.

6. Designed for scalability using M2M and cloud technology, it represents a significant advancement in sustainable farming practices.

10. Applications

- **Home gardening**: NFT hydroponics is an ideal method for home gardening, as it allows for year-round cultivation of fresh herbs, vegetables, and fruits. The system can be set up in a small space and can be easily maintained, making it a convenient and cost-effective option for home gardeners.

- **Commercial agriculture**: NFT hydroponics is also used in commercial agriculture for growing crops such as lettuce, herbs, and strawberries. The system is highly efficient, as it requires less water and space compared to traditional farming methods, leading to higher yields and reduced costs.

- **Urban farming**: NFT hydroponics is becoming increasingly popular in urban farming, as it allows for the cultivation of fresh produce in urban areas with limited space. The system can be set up in rooftops, balconies, or indoor spaces, providing a sustainable and efficient method for urban farming.

- **Research and education**: NFT hydroponics is used in research and education to study plant growth and development in a controlled environment. The system allows researchers and students to manipulate the nutrient composition and environmental factors to study the effects on plant growth and development.

- Aquaponics
- Hydroponics
- Aeroponics

11. Future Scope

- Collaborative Research and Development
- Integration with Robotics
- Plant Breeding specifically for hydroponics
- Global Expansion and Sustainability Initiatives
- Consumer Engagement and Education
- Expansion into Space Agriculture
- Incorporation of better Sustainable Practices
- Blockchain Integration for Traceability and Transparency
- Community Engagement Platforms
- Partnerships with Food Tech Companies
- Regulatory Compliance and Certification

12. Acknowledgement

We would like to express our sincere appreciation to all the individuals who contributed to the success of our project "Hydroponics Based Precision Farming with Feature Optimization".

First and foremost, We would like to thank **Mr. Ramgopal Sahu** for his invaluable guidance and support in PCB design, enclosure design, component choices, and modifications. His expertise and experience played a crucial role in the successful implementation of our project. His suggestions on plant choices were also very helpful in achieving our goals.

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We would also like to express our gratitude to our principal **Dr. Mrs. K. R. Joshi** for provision of state-of-the-art infrastructure, access to necessary resources and college's commitment to fostering an environment that encourages innovation, creativity, and hands-on learning.

Lastly, we would like to thank **Mr. Chandrakanth Bhode**, a certified fertilizer shop owner, for providing us with the best knowledge about fertilizer choices for hydroponics systems. His inputs were very valuable for the success of our project.

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