HyGrow

Remote Irrigation for Plant Care

Introduction

HyGrow is a cutting-edge agricultural technology designed to solve water scarcity and plant management through smart irrigation. This system combines the Internet of Things (IoT) with precision agriculture by using sensors and an ESP32 microcontroller to monitor key environmental factors such as soil moisture, temperature, and humidity.

The system's strength lies in its real-time data collection and analysis capabilities. HyGrow processes environmental data to make informed decisions about water needs using machine learning algorithms, particularly linear regression. This prediction ensures efficient water use and supports healthy crops while reducing waste.

HyGrow's user interface, comprising a web application and a mobile app, offers unprecedented control and monitoring capabilities to farmers and agricultural professionals.

Users can access real-time updates on their crops' conditions, manually adjust irrigation schedules, and receive alerts about potential issues from remote locations. The implementation of HyGrow has shown promising results in initial trials, demonstrating significant improvements in water efficiency and crop health.

By providing a data-driven approach to irrigation, the system addresses the dual challenges of resource conservation and agricultural productivity. As global concerns about water scarcity and sustainable farming practices continue to grow, HyGrow emerges as a timely and practical solution, paving the way for more sustainable and technologically advanced agricultural methods.

Problem Definition

- Water scarcity and inefficient irrigation methods are major issues in agriculture resulting in overwatering, under-watering, and resource waste.
- The traditional irrigation systems lack real-time data and adapting to environmental conditions.
- These inefficiencies result in detoriation of crop health, higher operational costs, and unsustainable water usage. Due to scarcity, there is an urgent need to find new solutions to optimize water use while ensuring sustainable agriculture.
- With the increasing global concerns about water scarcity and permaculture practices, HyGrow comes out in a timely and impactful manner, paving the way for sustainable agriculture and technology.

Objective

The objective of the our project is to improve agricultural water management by developing an IoT-enabled smart irrigation system that monitors real-time data and uses machine learning algorithms to optimize water usage and increase crop yields.

Our project aims to achieve:

1. Optimal usage of water:

- Implementing data-driven irrigation system that reduce water waste by providing only the water needed for crops based on current environmental conditions.

- Sensors continuously monitor conditions such as humidity, temperature, and moisture to ensure efficient distribution of water.

2. Improve crop health:

- Ensure plants receive adequate water and prevent overwatering or underwatering which can affect crop growth and health.

- Algorithms predict irrigation needs based on real-time data, further increasing crop yields and productivity.

3. Remote Irrigation:

- Providing a user-friendly web application and mobile app so users can control irrigation from any location.

- Allowing users to adjust irrigation schedules manually and receiving instant updates on crop conditions and be notified of adverse effects.

4. Promoting sustainable farming practices:

- Address global concerns about water scarcity by developing systems that reduce agricultural water use.
- Promotes sustainable farming by offering solutions that increase productivity, reduce environmental impact, and help protect important water resources.
- Provide farmers with insights into crop health, water usage, and water efficiency through data visualization and predictive analytics.

By achieving these goals, our work has become a solution for precision agriculture, solving the problems of water scarcity and agricultural productivity, paving the way for sustainable farming practices.

Ideas

1. Solving water scarcity:

- One of the motivations behind HyGrow is the growing concern about water scarcity worldwide. Since agriculture is the largest consumer of freshwater, we need a smart water system that will improve water quality while increasing the efficiency of sustainable agriculture.

2. The potential of IoT in precision agriculture:

- The rapid development of the Internet of Things (IoT) and its potential to change business has encouraged us to use this technology for agriculture. By integrating smart sensors and real-time data collection, we can create a system that monitors the environment and makes water flow more precise and efficient.

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3. Automation increases efficiency and convenience:

Traditional irrigation methods are labor-intensive and often inefficient, leading to excessive water use and uneven crop yields. The concept of automating irrigation through real-time monitoring and control inspired the creation of HyGrow, which allows farmers to manage their fields better and more easily

4. Machine Learning to Predict Irrigation:

The concept of using machine learning algorithms (like linear regression) to predict irrigation needs based on historical and live data is key to HyGrow's creation. This prediction will allow farmers to make informed decisions, reduce water waste, and increase crop yields.

5. Access to remote areas to improve management:

The need for farmers to manage crops from remote locations, especially in the processing of large projects, has given rise to the idea of developing mobile and web applications.

Through these platforms, users can monitor the environment, adjust irrigation schedules and receive alerts, thus making agriculture more flexible and responsive.

6. Support sustainable agriculture:

We want to create solutions that not only improve water management but also support sustainable agriculture by reducing resources and making it more efficient.

7. Increase yields and reduce costs:

Another important strategy is to help farmers increase yields while reducing water and operating costs. By providing precise irrigation based on the needs of the plants, HyGrow aims to help farmers achieve better crops and better economic and environmental returns on investment.

System Design

Hardware Design

Sensors:

The soil moisture sensor is used to measure soil moisture.

Temperature and humidity sensors to track environmental changes.

Microcontroller:

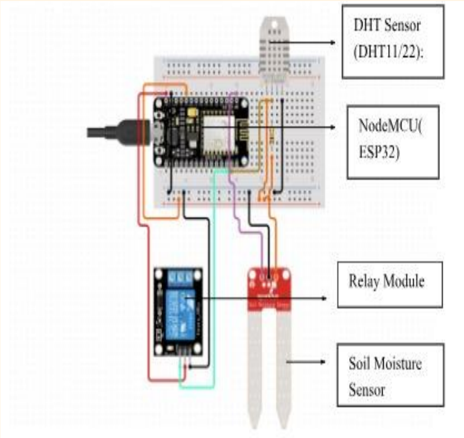
ESP32 microcontroller is used to collect data from sensors, process the data, and communicate with other devices.

Power:

Power control system with battery to ensure uninterrupted operation.

Communication module:

Integrating Wi-Fi modules to realize wireless communication between devices and the cloud for remote control.



Software Design:

- Arduino code for ESP32 interacts with sensors, process data, and control actuators.
- Using machine learning algorithms (like linear regression) on the server side to predict water demand based on real-time data.

- Local databases (like MySQL) are used to store environmental and system information for future use and analysis.

- A mobile app built using react native
- A web application built using Web API, HTML, CSS and Javascript

User Interface:

- Users will be able to monitor real-time data, manually adjust irrigation settings, and receive notifications with the help of a web-based dashboard and mobile app.

- Environmental data can be seen through graphs and charts.

- The interface allows manual control of irrigation schedules.

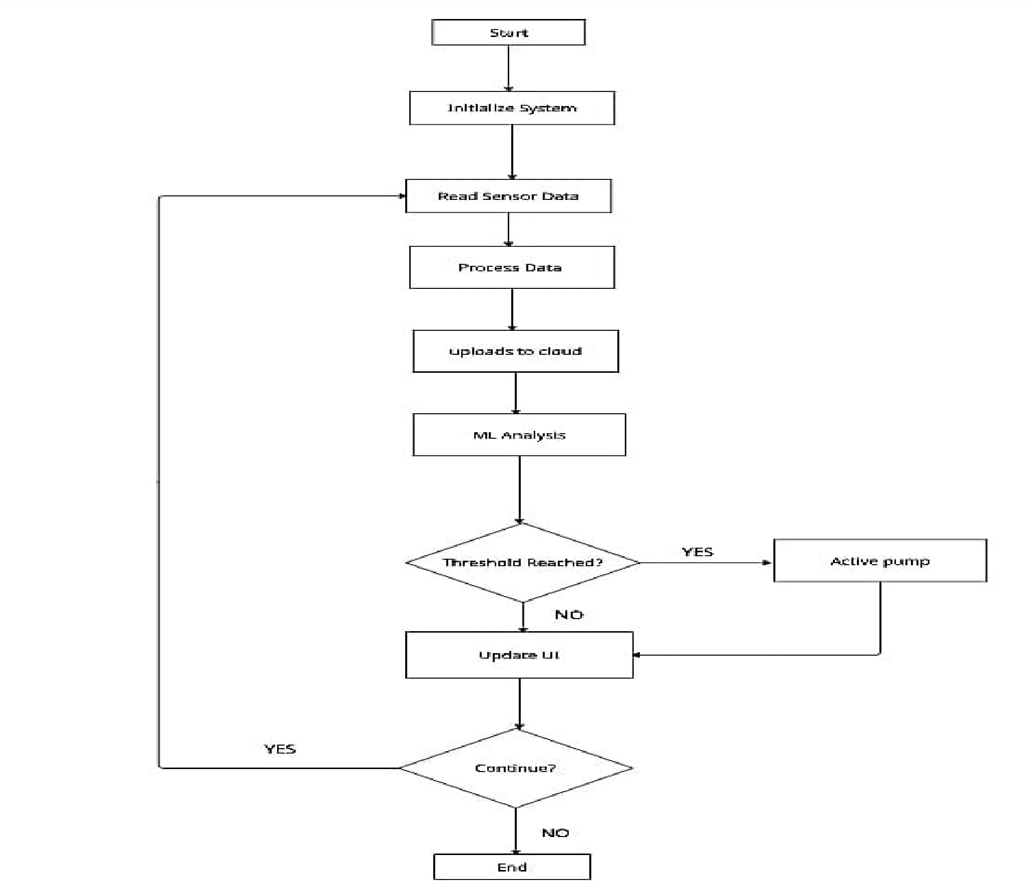
- Send real-time notifications for issues like low water levels, or abnormal environmental conditions via email, text, or app.

Networking and connectivity:

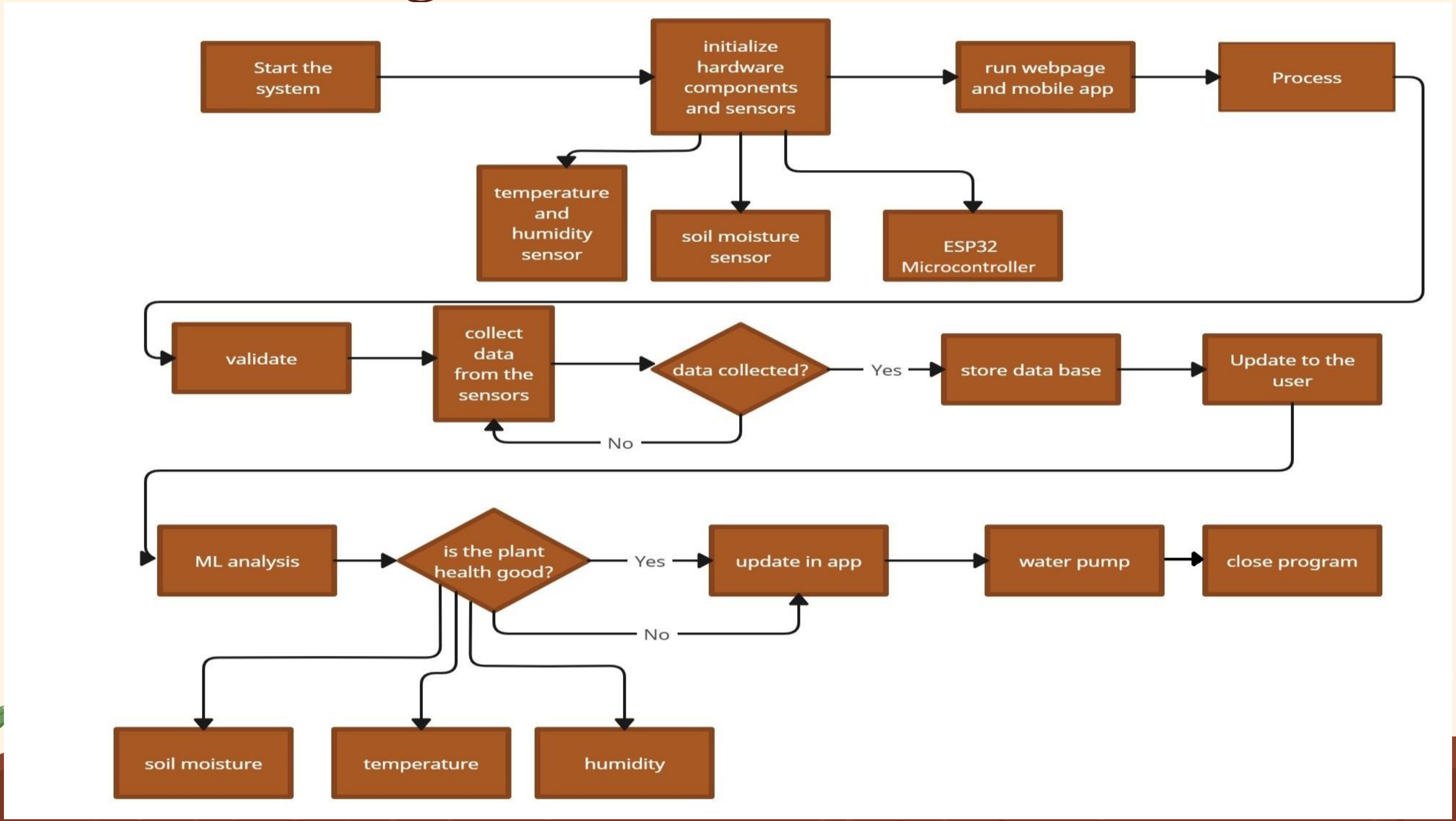
- The system is connected to the internet for remote access.

- The design of database services to store and retrieve data and run machine learning models.

Flowdiagram



Detailed Design



Start the System:

Initial step to begin system operations.

Initialize Components:

Setup of hardware and sensors including:

- Temperature & Humidity Sensor
- Soil Moisture Sensor
- ESP32 (Microcontroller for network operations)

Run Web & Mobile App:

Activate interfaces for remote monitoring and control.

Data Collection:

Collect sensor data after initialization.

Validate the collected data.

Decision: Data Collected?

- Yes:Store data in a database and update the user.
- No:Retry collecting data from sensors

ML Analysis:

Analyze data to evaluate plant health.

Decision: Is Plant Health Good?

Yes:Update the app, activate the water pump, and proceed to close the program.

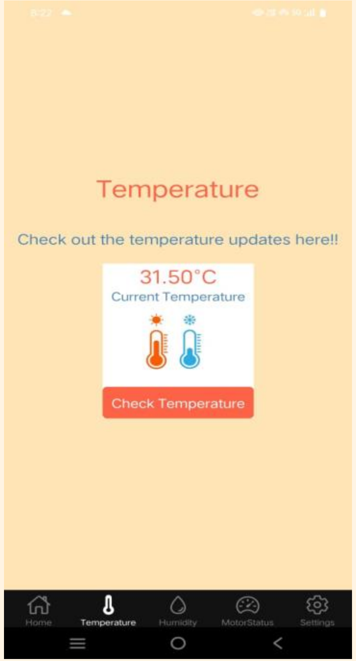
No:Perform corrective actions on soil moisture, temperature, or humidity.

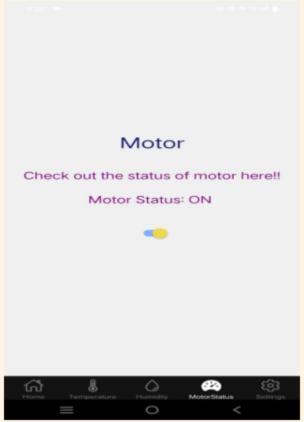
Tools and Technology Used

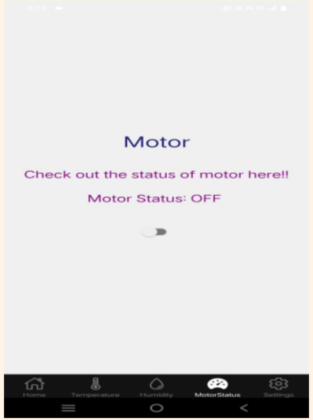
- **Python ->**Used for machine learning tasks to analyze the health of the plants based on sensor data.
- **React (React Native) ->**Built the mobile app for real-time monitoring and control of the system on the go.
- **HTML, CSS, JavaScript ->**Developed the web interface, allowing users to interact with the system through a browser and visualize data.
- **ESP32 Microcontroller->** A microcontroller used to connect the hardware sensors and manage communication between them and the software.
- **Sensors ->**Temperature & Humidity Sensor: Measures environmental factors around the plants.
  Soil Moisture Sensor: Monitors the water content in the soil to ensure optimal plant conditions.
- **Database ->**Used for storing all the data collected from the sensors, enabling further analysis and reporting(MySQL).

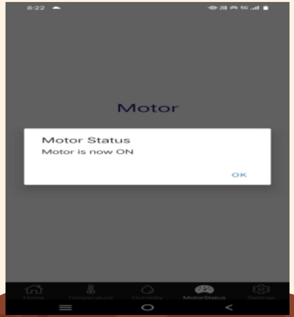
Screen shots of output

Mobile App:



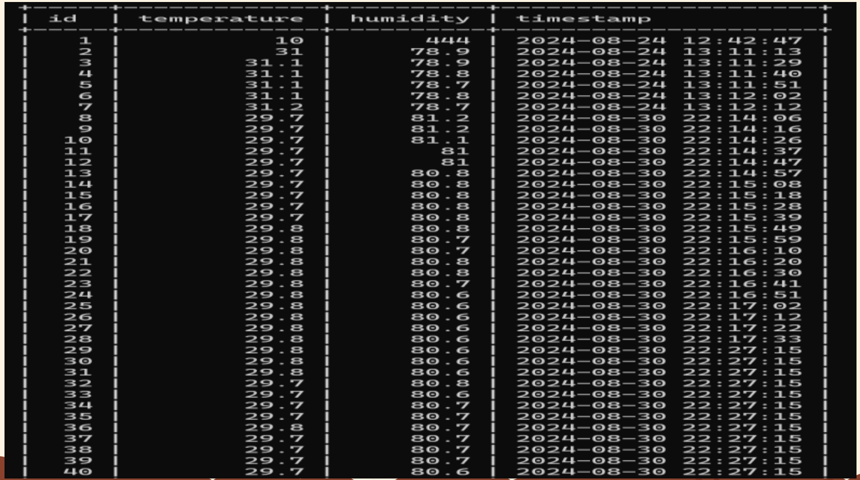






Webpage:

Database:



id	temperature	humidity	timestamp
1	10	444	2024-08-24 12:42:47
2	31	78.9	2024-08-24 13:11:13
3	31.1	78.9	2024-08-24 13:11:29
4	31.1	78.8	2024-08-24 13:11:40
5	31.1	78.7	2024-08-24 13:11:51
6	31.1	78.8	2024-08-24 13:12:02
7	31.2	78.7	2024-08-24 13:12:12
8	29.7	81.2	2024-08-30 22:14:06
9	29.7	81.2	2024-08-30 22:14:16
10	29.7	81.1	2024-08-30 22:14:26
11	29.7	81	2024-08-30 22:14:37
12	29.7	81	2024-08-30 22:14:47
13	29.7	80.8	2024-08-30 22:14:57
14	29.7	80.8	2024-08-30 22:15:08
15	29.7	80.8	2024-08-30 22:15:18
16	29.7	80.8	2024-08-30 22:15:28
17	29.7	80.8	2024-08-30 22:15:39
18	29.8	80.8	2024-08-30 22:15:49
19	29.8	80.7	2024-08-30 22:15:59
20	29.8	80.7	2024-08-30 22:16:10
21	29.8	80.8	2024-08-30 22:16:20
22	29.8	80.8	2024-08-30 22:16:30
23	29.8	80.7	2024-08-30 22:16:41
24	29.8	80.6	2024-08-30 22:16:51
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28	29.8	80.6	2024-08-30 22:17:33
29	29.8	80.6	2024-08-30 22:27:15
30	29.8	80.6	2024-08-30 22:27:15
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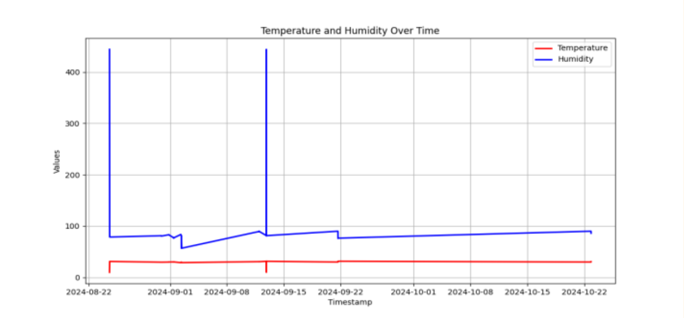
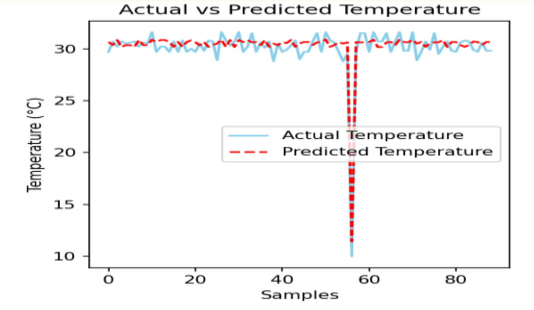
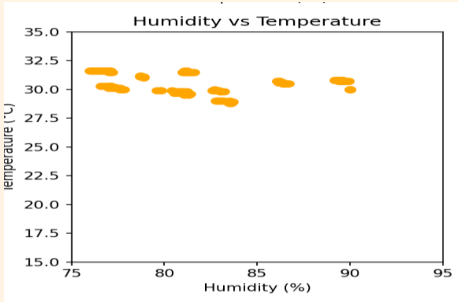
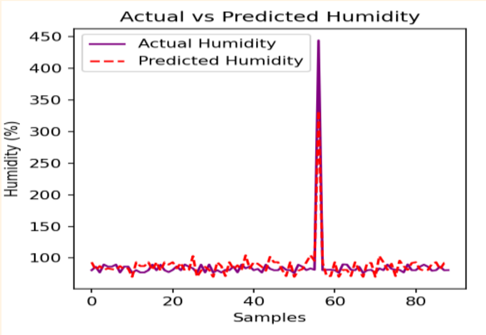
36	29.8	80.7	2024-08-30 22:27:15
37	29.7	80.7	2024-08-30 22:27:15
38	29.7	80.7	2024-08-30 22:27:15
39	29.7	80.7	2024-08-30 22:27:15
40	29.7	80.6	2024-08-30 22:27:15

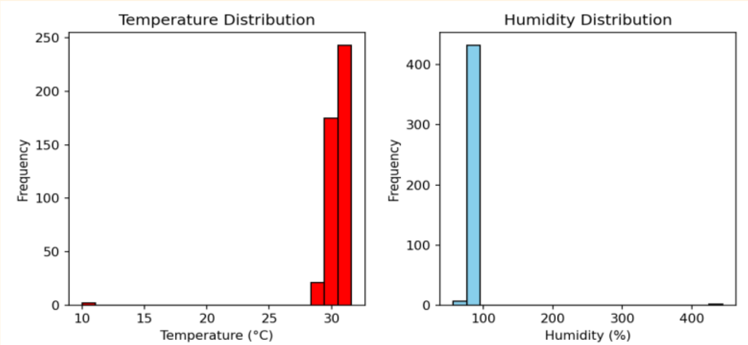
Machine Learning:

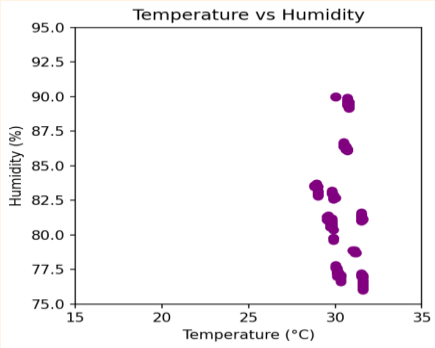












Results and Discussions

Figure 4 measures temperature (red) and humidity (blue) over time from August 25, 2024 to September 2, 2024. Humidity starts very high and then drops to around 100 units, stabilizing with an 80 to 100 unit swing. Temperature remains relatively stable with small fluctuations. The immediate drop in atmospheric humidity could be due to a change in weather conditions or re-calibration of equipment. To draw accurate conclusions, analyzing the quality of the data and the surrounding context such as the weather conditions or measurement methodology can help understand these patterns.

Figure 5 compares the actual temperature (solid light blue line) with the predicted temperature (dashed red line) for several samples. The actual temperature peaks at about 31°C, while the predicted temperature shows a smoother change, indicating that the model does not perform well during sudden changes.

Figure 4:

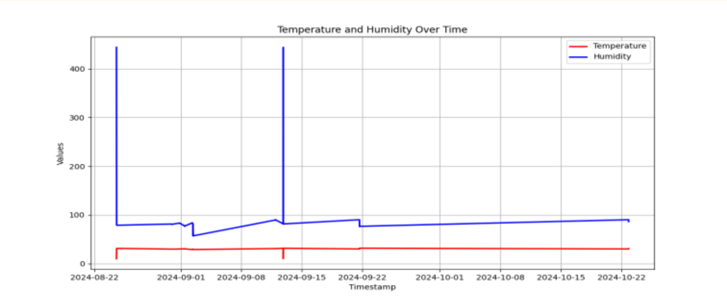


Figure 5:

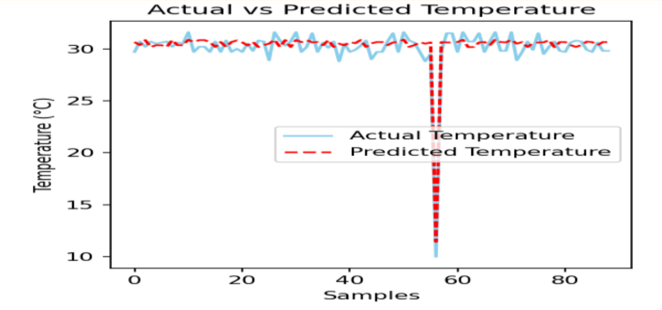


Figure 6 compares the actual soil moisture (solid red line) and the predicted soil moisture (dashed red line). The model tends to overestimate humidity levels, especially during rapid increases, indicating that it needs further tuning to handle extreme conditions.

Figure 8 depicts another scatter plot of humidity versus temperature. In contrast to the previous plot, this graph shows an inverse relationship between humidity and temperature. As temperature increases, humidity tends to decrease. This inverse proportion is consistent across the data range and provides valuable insights for climate modeling and understanding how temperature changes affect soil moisture.

Figure 8:

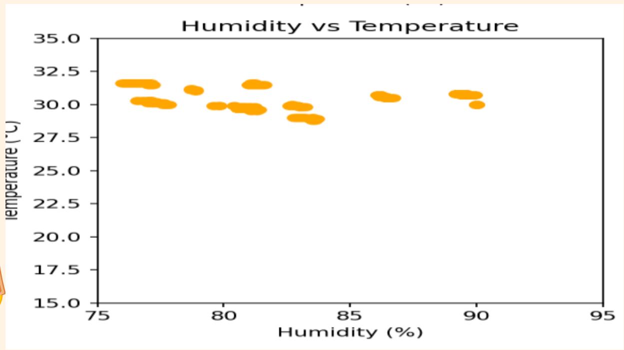
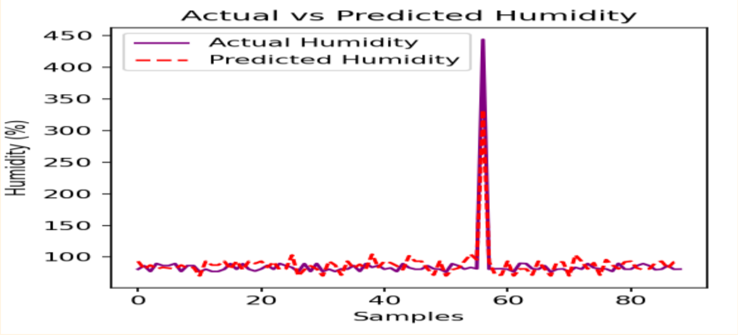


Figure 6:



Analysis of Model Performance:

The HyGrow system utilizes Linear Regression for
predicting humidity based on temperature. The relationship between input (temperature) and output (humidity) variables is modeled in the form of a
straight line:

$y = m0 + m1x$ (1)

Where:

- y is the predicted humidity
- x is the independent variable (temperature)
- m0 is the intercept of the line
- m1 is the slope of the line

The model's performance is evaluated using the coefficient of determination (R2), which measures the variance in the independent variable (temperature) with the dependent variable (humidity). R2 ranges from 0 to 1, where 1 indicates a perfect fit.

The equation for the coefficient of determination is:

R^2 = 1 −(SSres/SStot)

Where:

• SSres is the residual sum of squares

• SStot is the total sum of squares

Our initial results show a strong correlation between temperature and humidity, with an R2 value of 0.85, indicating that our model explains 85

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●Yield Forecasting and Assessment of In terannual Wheat Yield Variability Using Machine Learning Approach in a Semi-Arid Environment Hafiza Ham rah Kanwal1,*, Ishfaq Ahmad2 , Ash faq Ahmad3 and Yongfu Li4 1School of Computer Science, Chongqing Univer sity of Posts and Telecommunications, Chongqing, China; University of Agri culture,Chongqing, China (link)

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Thank You!!