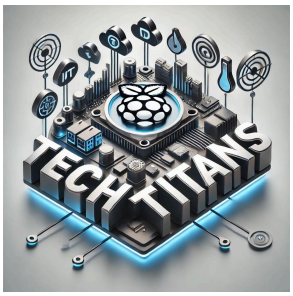
# Bharat Dome Innovation Pvt. Ltd.

Internship 2024-25




## Raspberry Pi based Weather Station

## By TECH TITANS

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## Under the guidance of

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# Table of Contents

# Abstract

This project presents the design and implementation of a weather station using a Raspberry Pi. The weather station collects real-time data on various weather parameters, including temperature, humidity, atmospheric pressure, wind speed, wind direction, and rainfall, pm2.5 and pm10. The collected data is then processed and displayed for remote monitoring and analysis. The system utilizes a combination of sensors, including a BME280, an anemometer, wind vane, rain gauge and a laser PM2.5 SDS018 for sensing particulate matter. The Raspberry Pi controls the data acquisition process, processes and transmits the data using Wi-Fi connectivity. The web page provides a user-friendly interface for visualizing the collected data in real-time and historical trends. The project aims to provide a cost-effective and versatile solution for weather monitoring, enabling users to make informed decisions based on weather conditions.

# Introduction

Weather stations have been instrumental in meteorological research and forecasting for centuries. Since our college is on an elevated platform and lacks a weather station that can monitor weather conditions we took up this problem statement in order to develop a feasible solution.

This project presents the design and implementation of a weather station built around a Raspberry Pi, a versatile single-board computer. The Raspberry Pi, coupled with a variety of sensors, allows for the collection of real-time weather data. The collected data is then processed and displayed on a webpage for analysis and visualization. This project will discuss the components used, the data acquisition and processing techniques, and the web-based interface for monitoring.

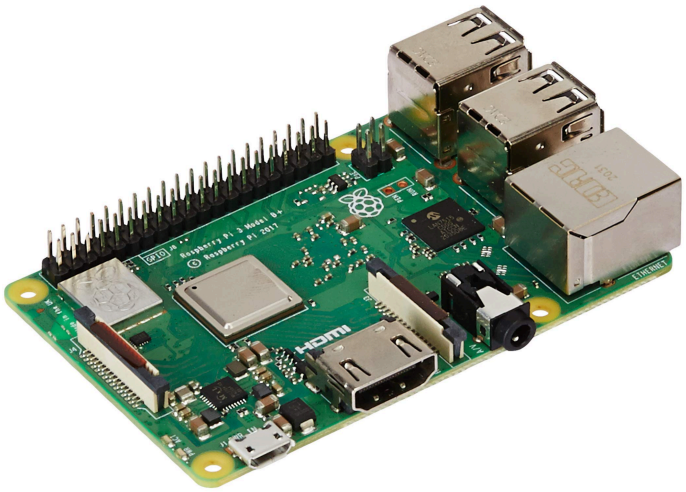


Fig. 1 Raspberry Pi 3 Model b+

# Nature of Work Carried out

We have divided the entire project into 7 major tasks and below is the breakdown of each task.

## Task 1 - Sensor selection and hardware setup

- Choose appropriate sensors for the weather station and assemble them on a breadboard.
- Research and source the required sensors (BME280 for temperature, humidity, pressure, anemometer and wind vane for wind speed/direction; rain gauge for rainfall).
- Ensure accurate data collection.
- Calibrate BME280 for temperature, humidity, and pressure.
- Calibrate wind sensors and rain gauge (debounce circuitry).

Fig. 2 BME280

## Task 2 - Sensor integration and enclosures

- Build robust, outdoor-ready enclosures.
- Design weatherproof enclosures with ventilation for BME280.
- Secure sensor cables with waterproof glands.
- Test sensors in different environmental conditions.

## Working mechanism of Rain Gauge

- The rain gauge uses a tipping bucket mechanism with a Hall sensor.
- When 2.5 ml of rainwater fills the bucket, it tips, triggering the sensor to record the event as a fixed rainfall amount.
- Paired with an anemometer, this setup provides real-time data on rainfall and wind speed for accurate weather tracking.

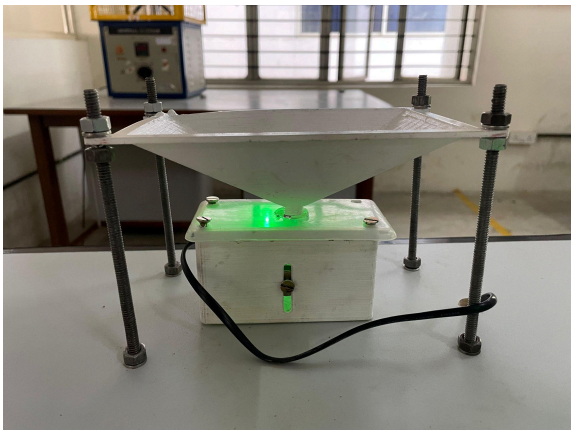


Fig. 3 Rain gauge

## Working mechanism of Wind Vane system for direction detection

- Wind Vane Body: 3D-printed design with a tail fin to ensure directional stability.
- Hall Effect Sensors (4): Used for magnetic field detection to determine the orientation of the wind vane. Each sensor detects the magnetic field from a magnet aligned with the vane.
- Detection Capability: The system can determine up to 8 distinct directions (N, NE, E, SE, S, SW, W, NW).
- The wind vane aligns itself with the wind direction.
- Hall Effect Sensors: Positioned around the vane, each sensor reacts when aligned with a magnetic field, producing unique signals for each direction.
- Direction Encoding: Based on sensor signals, the Raspberry Pi interprets and maps the vane position to one of the 8 cardinal and intermediate directions.

- Raspberry Pi processes these signals in real-time.

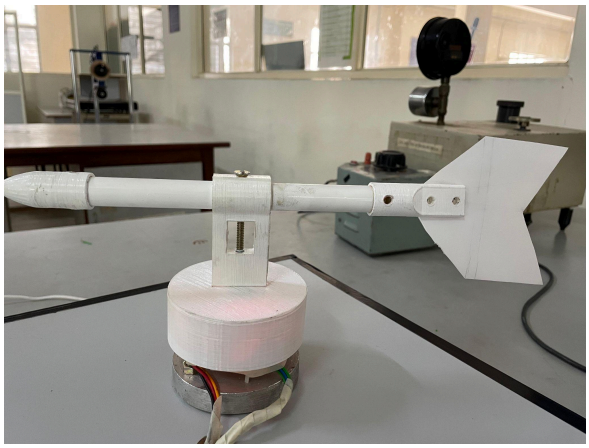


Fig. 4 Wind vane

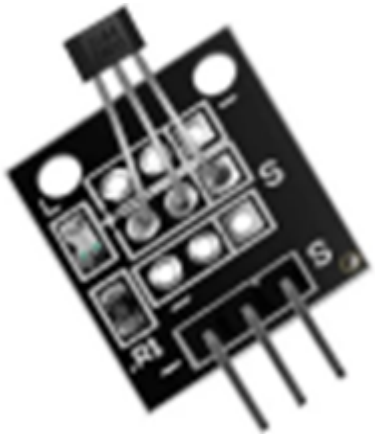



Fig. 5 Hall effect sensor

## Working mechanism of Anemometer

- Magnetic Detection: Anemometer's rotating disc has a magnet on one arm. A Hall effect sensor detects each rotation as the magnet passes by.
- Pulse Generation: Each pass generates a pulse, counted by the Raspberry Pi's GPIO.
- Wind Speed Calculation: Python script on the Raspberry Pi calculates wind speed based on pulse frequency and a calibration factor.

Fig. 6 Anemometer

## Working mechanism of Particulate Matter Sensor

- The SDS018 - Laser PM2.5 Sensor SDS018 V2 Air Quality Sensor uses principle of laser scattering to get the particle concentration between 0.3 to 10um in the air.
- The interface is digital UART output and built-in fan is stable and reliable.
- For our purposes, we are focusing on PM2.5 and PM10 measurements.

Fig 7. Laser PM2.5 Sensor SDS018

## Task 3 - Communication Interface Design

- Ensure reliable sensor communication.
- Implement I2C (BME280)
- Test circuits for rain gauge/anemometer (pulse signals).
- Add error-checking and fail-safes for sensor data.

## Task 4 - Data transmission and power management

- Optimize power and data transmission.
- Apply power-saving strategies (disable unused components).
- Set up WiFi for data transmission.
- Test power stability (battery/solar backup options).

## Task 5 - Data collection and sensor-software integration

- Python scripts to capture data from the sensors
- Implement data filtering algorithms
- Format the data as required.

## Task 6 - Data logging

- Modify the sensor data into a CSV format.

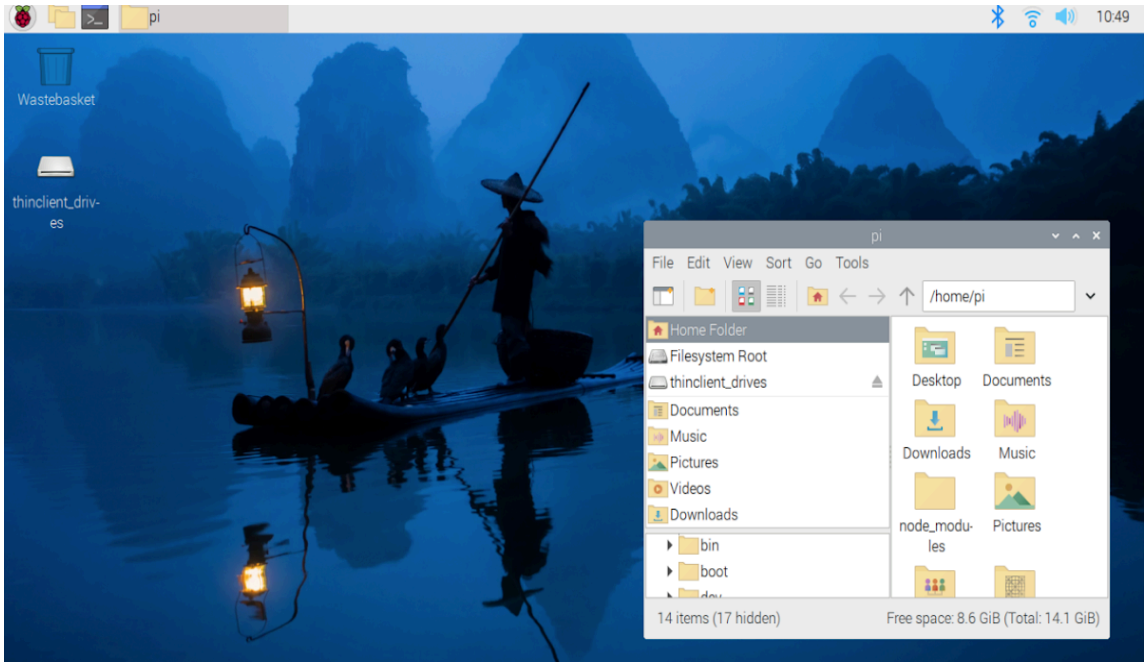
## Task 7 - Data visualisation

- Develop a UI using web technologies like HTML, CSS and Flask
- Use matplotlib for data visualization

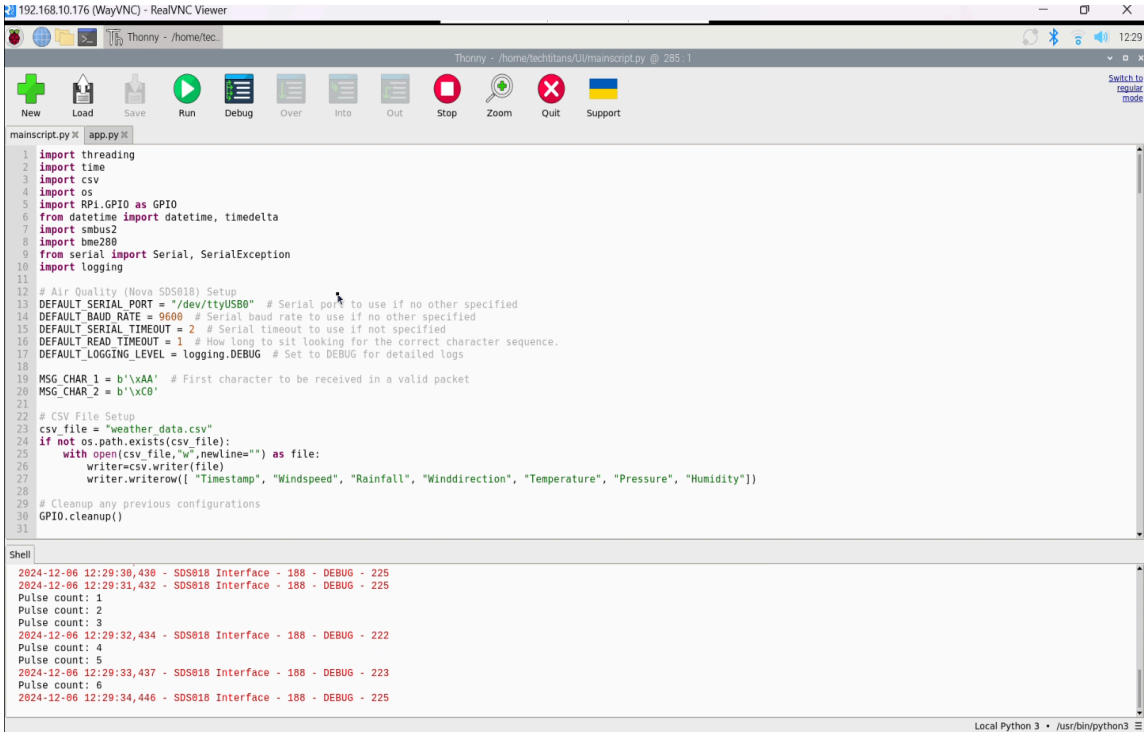
# Results

1. Assembly of components

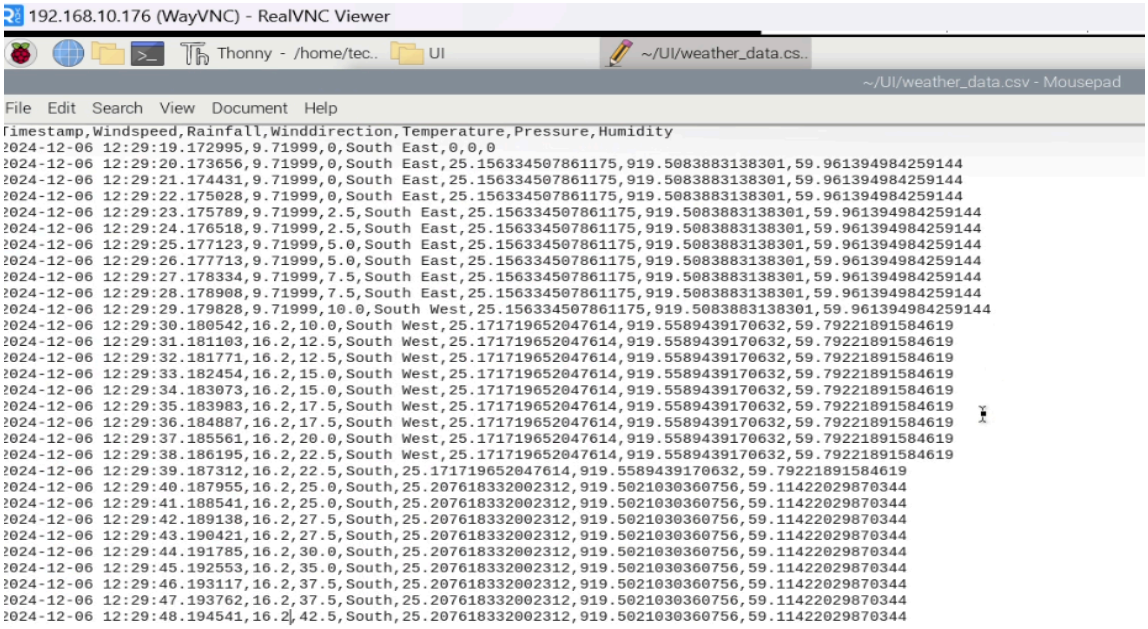

2. Setup the raspberry pi OS with the help of RealVNC Viewer.



3. A glimpse of the mainscript to capture sensor readings.




4. CSV files that recorded all the sensor readings



192.168.10.176 (WayVNC) - RealVNC Viewer

Thonny - /home/tec.. UI ~/UI/sensor_readings..

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```
imestamp,PM10_label,PM10_value,PM2.5_label,PM2.5_value
024-12-06 06:59:19,PM10,19.7,PM2.5,10.6
024-12-06 06:59:20,PM10,19.1,PM2.5,10.5
024-12-06 06:59:21,PM10,19.9,PM2.5,10.6
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024-12-06 06:59:41,PM10,18.5,PM2.5,10.0
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024-12-06 06:59:47,PM10,17.3,PM2.5,9.7
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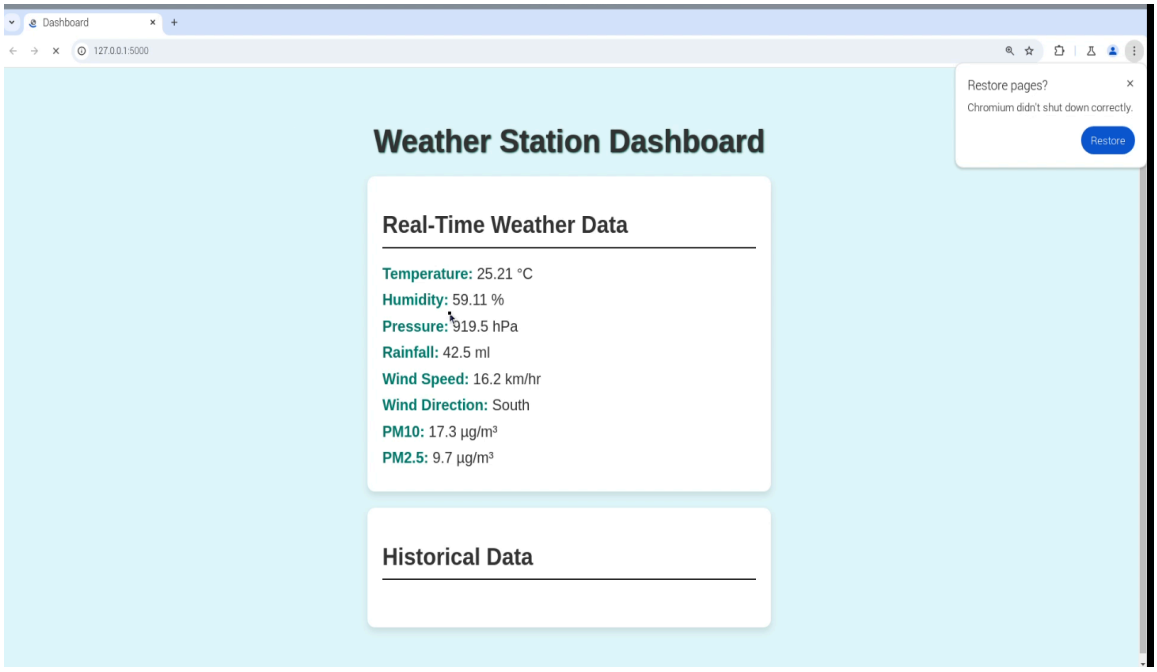
5. Dashboard that displays the latest data collected



6. Visualization using matplotlib

# Conclusion

The developed Raspberry Pi-based weather station successfully collects, processes, and transmits real-time weather data. The web-based interface enables remote monitoring and analysis, making it a valuable tool for various applications. Future improvements could include integrating additional sensors such as solar radiation sensors. Additionally, exploring machine learning techniques for predictive weather forecasting would enhance the system's capabilities. By continuing to develop and refine this technology, we can gain deeper insights into weather patterns and make more informed decisions in various fields.

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