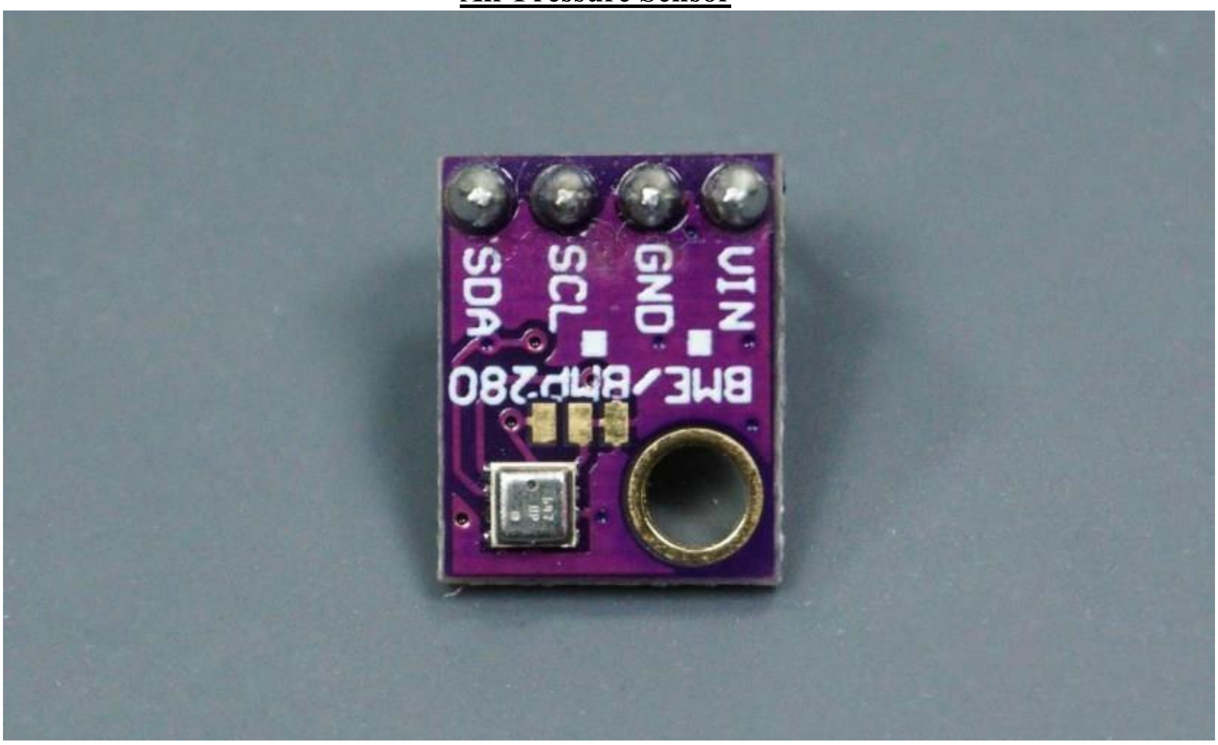
SIT225: Data Capture Technologies
Task 9.1P: Use Case Design
Panopto Link: https://deakin.au.panopto.com/Panopto/Pages/Viewer.aspx?id=4ffa3bc6-48bf-4e61-b091-b1f200211fcc
Github:
https://github.com/nhatthai2004/SIT225/tree/03049b95f00f2f96345aa420b76418c1354fc6bd/week-9

Air Pressure Sensor



1. Introduction

Weather forecasting has always been a useful tool in daily life, whether you're a farmer preparing for the upcoming crop or just a person choosing whether to wear an umbrella to work. But what if you could install your own home weather station so you could predict shortterm weather patterns like temperature fluctuations or the likelihood of rain? This project's only tool—the BME280 sensor, a compact yet capable thermometer, barometric pressure gauge is designed to achieve precisely that. This study demonstrates how even basic environmental data may provide valuable insights into local weather conditions, as it guides the reader through the process of configuring a weather forecasting system using the BME280 sensor.

2. Literature Review

I. Weather Forecasting Systems

Weather stations and forecasting tools have been used extensively for decades, utilizing advanced meteorological equipment and complex algorithms to predict weather conditions. With the advent of the Internet of Things (IoT), it is now possible to develop small, accessible systems to collect and analyze data locally, making personal weather stations available to the average user.

II. Sensor-Based Weather Prediction

The BME280 sensor, manufactured by Bosch, is a popular sensor for environmental monitoring due to its ability to measure temperature, humidity, and barometric pressure with high precision. Several projects have demonstrated the effectiveness of BME280 in tracking weather parameters, but this study takes it a step further by integrating data analysis and real-time forecasting with IoT-based cloud storage.

III. Forecasting Techniques

Traditional meteorological models rely on sophisticated physics-based methods, while data-driven machine learning approaches are increasingly used for short-term forecasting. This study focuses on simple regression-based modeling for predicting temperature changes and rule-based models for rain prediction.

3. Methods

I. Hardware Components

- **BME280 Sensor:** A compact sensor capable of measuring temperature, humidity, and pressure.
- **Arduino Nano 33 IoT:** This microcontroller is used for collecting data from the BME280 sensor and transmitting the readings to the cloud. The built-in WiFi module makes it suitable for cloud communication.

II. Data Collection

The BME280 sensor is connected to the Arduino Nano 33 IoT, which reads data at periodic intervals. To ensure data reliability, a hybrid storage approach is employed:

- **Local Storage:** Data is saved on an SD card connected to the Arduino to provide a backup in case of connectivity issues.
- **Cloud Storage:** Data is also periodically uploaded to Arduino Cloud, allowing remote access and long-term storage for further analysis.

III. Data Visualization

A Plotly Dash dashboard presents the real-time and historical data. The dashboard is interactive, allowing users to zoom into specific time frames, compare different weather parameters, and observe trends. This visualization approach makes it easy to derive insights from data at a glance.

IV. Forecasting Models

- **Temperature Forecasting:** A Linear Regression model is applied to past temperature data to predict short-term changes.
- **Rain Prediction:** A rule-based model predicts the likelihood of rain based on humidity and pressure thresholds (e.g., high humidity above 80% and dropping pressure indicate an increased likelihood of rain).

V. Alerts and Notifications

The system sends real-time alerts to users when significant changes are detected in weather conditions. Alerts, triggered by sudden drops in pressure or spikes in humidity, are sent via SMS or email to keep users informed.

4. Results

I. Data Analysis

The collected data showed noticeable patterns in temperature fluctuations and pressure changes, enabling accurate short-term forecasts using the linear regression model. Humidity spikes were correlated with potential rainfall, which was consistent with the predictions from the rule-based model.

II. Forecasting Accuracy

The Linear Regression model provided satisfactory predictions for temperature changes, while the rule-based model reliably indicated conditions favorable for rainfall. The combined approach proved effective in providing hyper-local weather forecasts.

5. Discussion

I. System Performance

The system effectively demonstrated how inexpensive hardware, such as the Arduino Nano 33 IoT and the BME280 sensor, can be leveraged to collect, analyze, and predict weather conditions. The dual-storage approach ensured data reliability, while the cloud connectivity enabled real-time monitoring and remote access.

II. Challenges and Limitations

- **Connectivity Issues:** The Arduino's dependence on a stable internet connection can limit real-time updates, but the local SD card mitigates data loss risks.
- **Simple Forecasting Models:** Although effective, the linear regression and rule-based models are simplistic. More complex machine learning models could provide improved accuracy and more detailed forecasts.

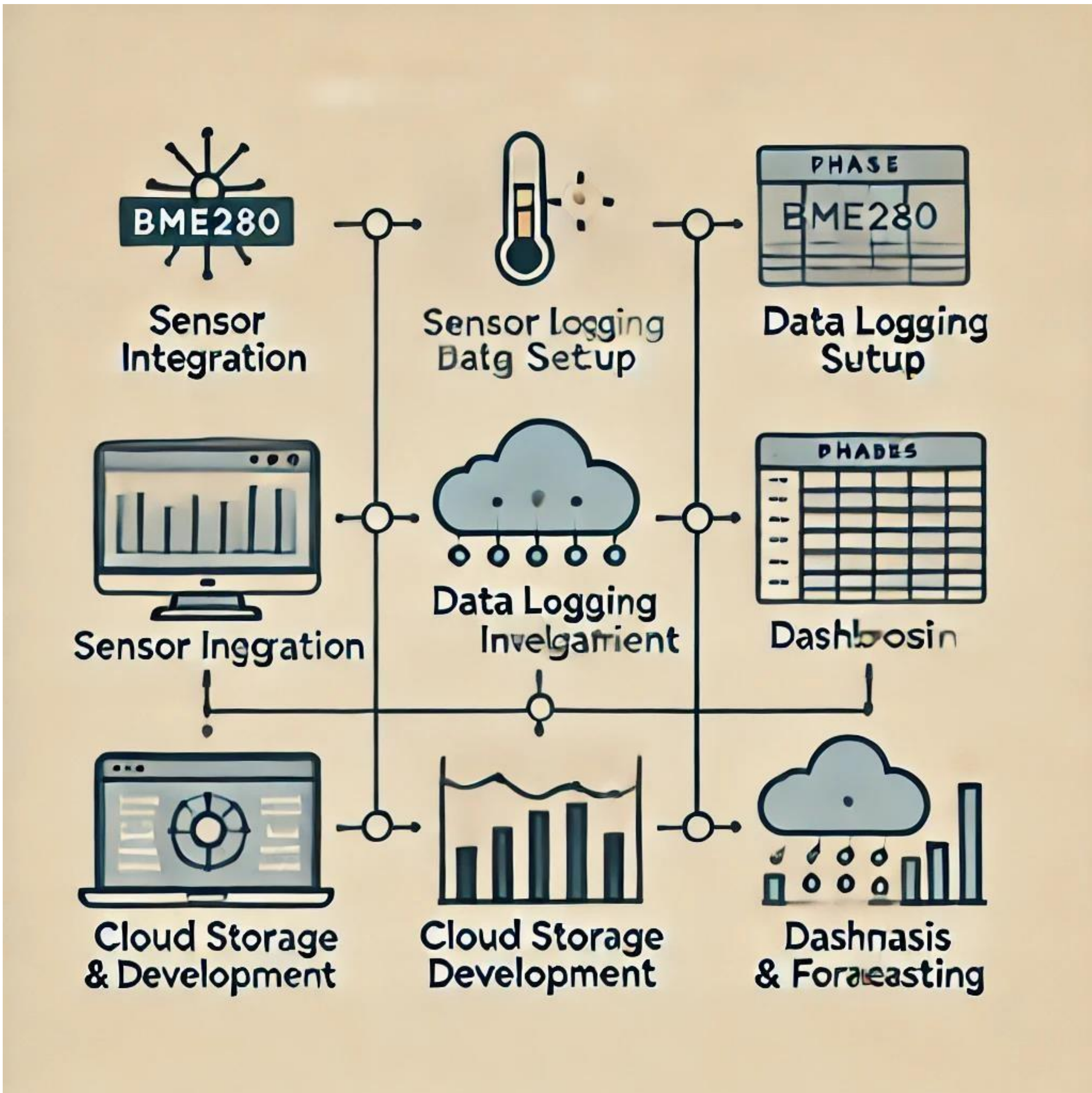
III. User Experience

The interactive dashboard enabled easy access to weather data and trends, making it suitable for both novice and experienced users. Real-time alerts via SMS or email were found to be a valuable feature for providing timely weather updates.

5. Conclusion

This project demonstrated the feasibility of developing a personal weather station using a BME280 sensor and an Arduino Nano 33 IoT. By using a dual-storage approach, an interactive visualization dashboard, and basic predictive models, the system provides users with a practical, localized weather forecasting solution. Future enhancements could further improve the forecasting accuracy and user experience, providing a more advanced tool for monitoring and predicting environmental conditions.

Gant Chart: How to connect through the BME280 sensor (air pressure)



References:

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- Adafruit Industries. **BME280 I2C or SPI temperature, humidity, and pressure sensor**. Adafruit. Retrieved September 21, 2024, from https://learn.adafruit.com/adafruit-bme280-humidity-barometric-pressure-temperaturesensor-breakout