Emerging Technologies

Samridhi Sehgal
Ujwal Kandi

Smart Air Quality Alert System

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Task 1

The challenge we're addressing is the escalating concern of air pollution and its direct impact on public health. As urbanization and industrialization grow, air quality deterioration is a pressing issue. Our solution merges GPS technology with air quality sensors to develop a practical, real-time air quality monitoring system.

This system not only provides users with up-to-date information on local air quality but also offers the capability to detect harmful gas leaks in industrial zones. By leveraging real-time sensor data and geofencing technology, our project can pinpoint the exact location of gas leaks from equipment in industrial areas and swiftly alert personnel to evacuate the affected region, enhancing safety and minimizing potential health hazards.

By the semester's end, we aim to showcase a working prototype that accomplishes the following key functionalities:

- **Real-time Air Quality Monitoring**: A mobile app that collects and displays real-time air quality data, enabling users to check air quality in their vicinity.
- **Geofencing Alerts**: Geofencing capabilities will be incorporated to alert users when they enter areas with poor air quality, offering insights to make informed decisions.
- **Historical Data and Trends**: The app will provide access to historical air quality data and trends, aiding users in planning activities based on past air quality patterns.
- **Personalized Recommendations**: Users will receive tailored recommendations, such as choosing healthier commute routes or adjusting outdoor plans to mitigate exposure to pollutants.

Our solution empowers individuals with the information needed to protect their health and make decisions that contribute to cleaner air and healthier communities.

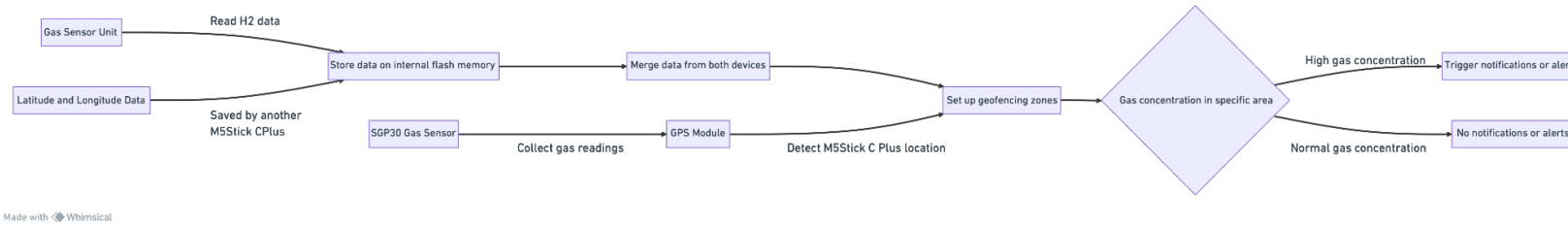
Task 2

Our approach to addressing the challenge of air quality monitoring using the M5 Stick, GPS sensor, and TVOC/eCO2 Gas Sensor Unit (SGP30) involves a comprehensive design with several key components.

Major Components:

- **M5 Stick**: At the heart of our solution is the M5 Stick, a compact and versatile device that houses the necessary microcontroller, display, and user interface. It serves as the central hub for data collection and user interaction.
- **GPS Sensor**: The GPS sensor provides essential location data. This location data is the foundation for geofencing and location-based air quality monitoring.
- **SGP30 Sensor**: The SGP30 sensor is responsible for measuring total volatile organic compounds (TVOC) and equivalent carbon dioxide (eCO2) levels, which are critical components of air quality assessment.
- **User Interface**: We will try to use the LCD display of M5 for generating user alerts, and simultaneously save the data on the internal memory to get the visualisations on our personal device such as a laptop.

Flowchart Overview: Drag the Image to zoom in



Data Collection:

The M5 Stick is responsible for collecting real-time air quality data from the SGP30 sensor. Simultaneously, it obtains GPS coordinates from the embedded GPS sensor, allowing for precise location tracking.

Data Integration:

The M5 Stick integrates air quality and location data, creating a unified dataset that is essential for accurate air quality assessment and geofencing logic.

Geofencing Logic:

Within the mobile app, geofencing parameters are defined. These parameters specify different zones with distinct air quality thresholds. The operating logic will compare the user's GPS coordinates with the defined geofencing zones.

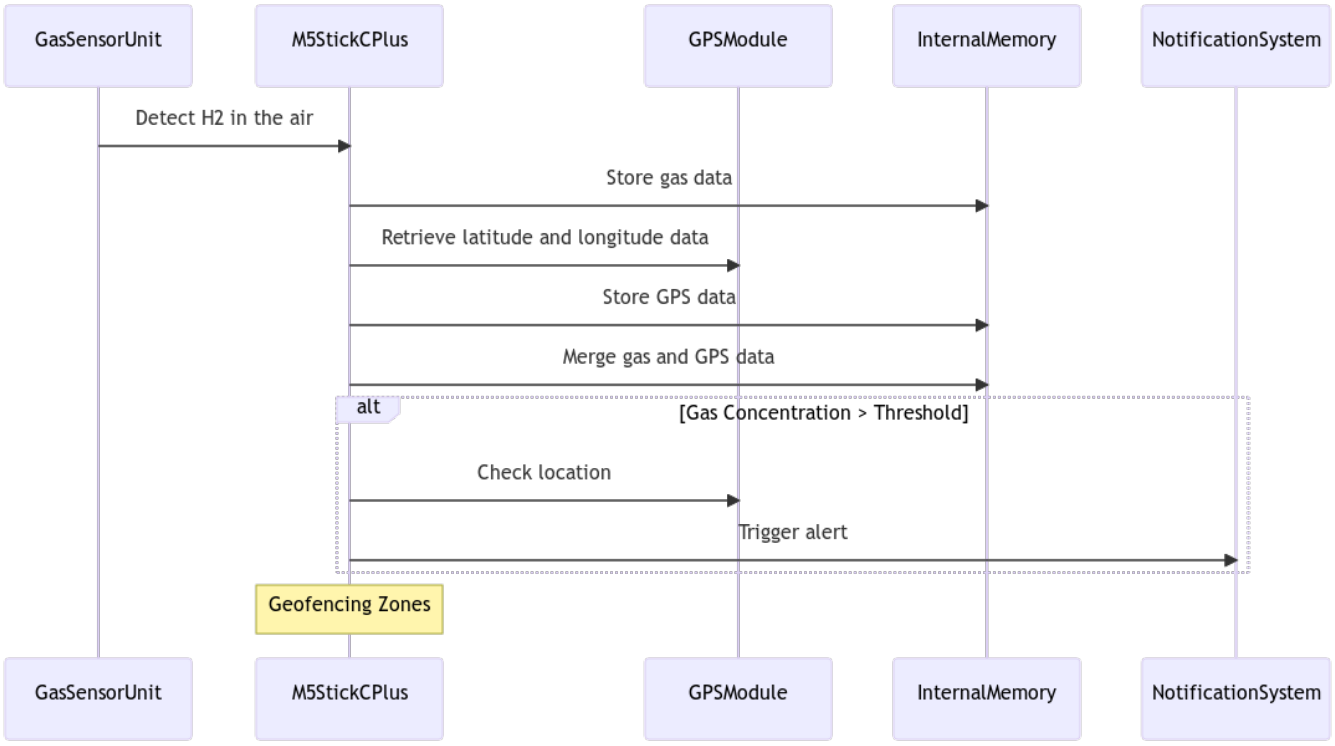
Alert Generation:

If the user enters a zone with air quality exceeding predefined thresholds, the system generates an alert, notifying the user of potential health risks.

Display and Recommendations:

The device displays real-time air quality data, including TVOC and eCO2 levels, in a user-friendly format. It alerts users to take necessary actions based on their location and the current air quality data. These recommendations empower users to make informed decisions to mitigate their exposure to pollutants.

Sequence diagram Overview:



The diagram depicts a system design for monitoring gas concentrations in the air using a Gas Sensor Unit connected to an M5Stick CPlus device. The Gas Sensor Unit detects H2 gas and stores the data on its internal flash memory. This requirement is verified through testing the sensor readings.

The chart also shows the requirement to merge data from the Gas Sensor Unit and a GPS module, which collects latitude and longitude data. The merging of the data is validated through integration testing.

The merged dataset is then used to set up geofencing zones, as indicated by the requirement. The geofencing zones are created using the merged data, and this setup is inspected to ensure its correctness.

Furthermore, the chart illustrates the requirement to trigger notifications or alerts based on gas concentration and location. When the GPS module detects that the M5Stick CPlus device has entered or exited a specific area with high gas readings, notifications or alerts are triggered. This functionality is tested to verify its reliability.

To achieve these requirements, the Gas Sensor Unit and GPS module are connected to the M5Stick CPlus device. The connections are visually inspected to ensure proper interface and functionality.

The M5Stick CPlus device contains both the Gas Sensor Unit and GPS module. Additionally, a mobile app is shown to contain the M5Stick CPlus device, indicating that the data and notifications/alerts are likely displayed through the mobile app.

Overall, this system allows for the detection of gas concentrations, merging of gas and GPS data, setup of geofencing zones, and triggering of notifications/alerts based on gas concentration and location.

While this represents our current design approach, we acknowledge that the project's final implementation may evolve during the development phase.

Task 3

To successfully develop our air quality monitoring solution using the TVOC/eCO2 Gas Sensor Unit (SGP30) and GPS sensor, we have specific needs related to these components:

- TVOC/eCO2 Gas Sensor Unit (SGP30) sensor for checking air quality (requested).
- GPS sensor (we've got one already from you).
- Two M5Sticks for both sensors.

Task 4

As we embark on this project, there are several concerns and potential pitfalls that we need to address:

- **Sensor Calibration**: Are the TVOC and eCO2 readings from the SGP30 sensor accurately calibrated, and can we rely on them for precise air quality measurements?
- **Data Accuracy**: How do we ensure that the GPS sensor provides accurate location data, especially in urban environments with signal interference or tall buildings?
- **Geofencing Precision**: Can we achieve a high level of precision in geofencing alerts, ensuring that users receive notifications only when they are truly within a specific zone with poor air quality?
- **Real-time Data Integration**: How do we effectively integrate and process real-time data from both sensors in a manner that provides users with up-to-date air quality information and alerts?
- **User Engagement**: How can we ensure that users actively engage with the device and make decisions based on the air quality information provided?
- **Handling Data Variability**: How can we handle variations in air quality data due to changes in weather conditions, traffic, or other environmental factors?
- **Scalability**: If the project is successful and adopted by a larger user base, how can we ensure scalability and data reliability?
- **Regulatory Compliance**: Are there any regulatory or privacy concerns related to collecting and processing location data and air quality information that we need to address?
- **User Experience**: How can we design a user-friendly interface that effectively communicates air quality data and recommendations to users without overwhelming them with technical details?

These are the key areas that we can think of where potential pitfalls may lie. We would further focus on addressing these challenges, especially in terms of sensor calibration, data accuracy, and geofencing precision. Additionally, any insights or best practices related to user engagement and privacy compliance would be invaluable.