Sensor Network Development for Gas Source Localization

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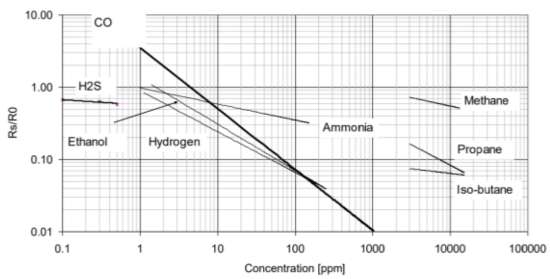
The dependable detection and prompt localization of gas leaks are vital in industries such as chemical plants, oil refineries, and mining. Undetected leaks can result in environmental damage, health risks, and catastrophic events. Consequently, developing sensor networks capable of detecting and pinpointing gas leaks has emerged as an imperative research domain. By interlinking gas sensors in a network, real-time data collection from various locations is enabled, facilitating analysis and visualization of leak locations, severities, and proliferation.

To build the network, sensor nodes were configured to communicate through MQTT protocol with a Python-based web server. The user interface permits interaction, offering data visualization received from the nodes, and enables transmission of diverse information back to the nodes. We then focused on two main tasks: managing power consumption for the sensor nodes, enhancing their lifespan and simplifying maintenance, and data calibration, necessary to ensure consistency and reliability of data across the nodes.

To manage the nodes' power consumption, the user can transmit various commands via the web interface, including disabling unused functionalities such as the wind module or gas sensor to conserve energy, and initiating sleep mode which engages the nodes in a custom sleep protocol.

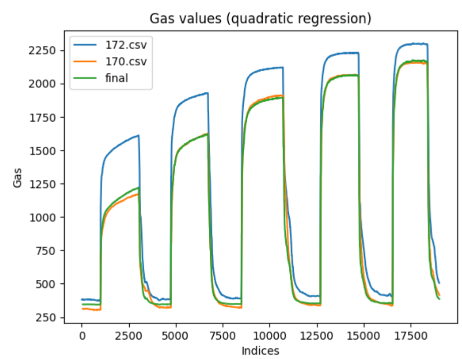
The data calibration process primarily centered on the gas input of the sensor, encompassing two types of calibration: one mapping raw sensor readings to actual gas concentrations, and a steady-state calibration ensuring uniformity in node responses under identical environmental exposure.

To transform raw data to real-world gas concentrations, we employed a bespoke function outlined in the documentation of the MICS 5524 sensor.



Distribution map for each gas type

The steady-state calibration involved sampling gas concentration data from two different sensor nodes, isolating the steady-state data, and executing a quadratic regression to harmonize both datasets. We then obtained three constants that are used to perform this regression on the specified sensor node.



Example of steady-state calibration on nodes 172 and 170

To validate the calibration process, we deployed the nodes in a wind tunnel for testing. The gas source was positioned centrally, and the node traversed horizontally to capture gas concentrations at various points within the tunnel. The results indicated that the steady-state calibration process was ill-suited for the dynamic environment of the wind tunnel, likely attributable to intermittent and unstable gas concentrations that prevented the nodes from attaining a stable gas concentration level.