

AEROVANT: A UAV-INTEGRATED MULTI - SENSOR PLATFORM FOR
HAZARDOUS GAS DETECTION, THREAT LEVEL CLASSIFICATION, AND
ENVIRONMENTAL MONITORING USING MACHINE LEARNING

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ABSTRACT

This study presents AEROVANT, a UAV-mounted electronic nose system for real-time hazardous gas detection and health risk classification in Cagayan de Oro, Philippines. The system integrates five MQ-series metal oxide sensors (butane, ethanol, LPG, hydrogen, ammonia) with environmental monitoring to overcome limitations of conventional fixed gas detection. A two-stage machine learning pipeline was implemented: sensor calibration using ensemble regression models (Random Forest, XGBoost) to convert raw signals into accurate parts-per-million concentrations, followed by a Multi-layer Perceptron neural network to classify cumulative health risks as “Stable” or “Critical” based on OSHA and ACGIH guidelines.

Calibration results show advanced nonlinear models achieved R^2 values above 0.99 for previously unstable sensors (MQ-3, MQ-9), outperforming baseline linear regression ($R^2 \sim 0.66$). The optimized MLP classifier reached 99.7% F1-score during validation, with perfect ROC-AUC and precision-recall metrics. Field deployment on 10,000 unseen samples yielded 97.54% balanced accuracy, confirming robust generalization. SHAP analysis revealed that sensors considered “unstable” due to temperature and humidity were among the most informative, with the model capturing complex conditional relationships.

The system maintained 2.2-second inference latency on Raspberry Pi 4B and sub-4-second cloud synchronization, enabling real-time operation during 15-minute UAV flights at altitudes up to 150 meters, the Wi-Fi communication limit. These results demonstrate that low-cost sensor arrays with intelligent machine learning pipelines can achieve performance comparable to industrial-grade systems, supporting emergency response and environmental monitoring.

Keywords: *Electronic Nose (E-Nose), gas leak detection, drone-based monitoring, sensor fusion, UAV*