AirLab - An Adaptive UAV-Based System for Reducing Uncertainty in Atmospheric Dispersion Modelling

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Emergencies like wildfires and industrial accidents threaten public health. Accurate predictions of pollutant dispersion are vital for timely protective actions, but atmospheric models often face uncertainty due to limited measurements and simplified physical assumptions. This project presents a three-pillar system—modeling, measurement, and procedure—that integrates predictive models with targeted UAV observations. This system prevents unrealistic predictions and enables faster, more reliable emergency responses. Using the HYSPLIT atmospheric dispersion model, we simulated pollutant transport under perturbed meteorological conditions to quantify sensitivity and uncertainty. UAVs equipped with atmospheric sensors were deployed along optimised trajectories targeting regions of highest predicted concentration and uncertainty. Real-time measurements were fed back to refine forecasts. The procedural pillar guided UAV deployment and assessed whether hazards exceeded health-based thresholds, enabling rapid responses. Dispersion patterns were highly sensitive to small uncertainties in initial meteorology, especially in complex terrain. The closed-loop system combining modeling and targeted UAV measurements consistently outperformed model-only forecasts. UAV-guided observations significantly reduced prediction uncertainty compared to uniform sampling, providing real-world validation where models were most uncertain. Integrating modeling with UAV-based observations in a structured, three-pillar framework enhances the reliability of atmospheric dispersion forecasts under uncertainty. This approach demonstrates a broadly applicable method for decision-making in real-time, high-stakes scenarios where predictions must be continuously validated by empirical data.

Awards Won:

Fourth Award of $600