FROM SENSING TO MAKING SENSE

Real-time In-situ Plume Characterization

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Real-time plume tracking of airborne released CBRNE (chemical, biological, radiological, nuclear, and explosive) agents is difficult to undertake during real events, with the source-term being rarely fully characterized. Any significant gaps in the relationship between actual conditions and plume models can lead to uncertainty in predictions of plume evolution for ground forces and incident response. To address this, Sandia National Laboratories is investigating the implementation of a threat-agnostic architecture for plume characterization that utilizes in-situ unmanned aerial vehicles (UAV) to adaptively sense plume characteristics. We have developed a simulation testbed for testing and visualizing plume tracking algorithms that allows for rapid testing in a low cost/risk environment. These proven algorithms can then be translated into flight-ready software. Current work is focused on an autonomous deployment capable of identifying the point of origin for an indoor-generated plume.

Most solutions for aerial plume tracking use pre-planned paths for collecting data with limited adaptability to changing meteorological conditions; resulting in slow, inefficient, and relatively uninformative data sets that require significant post processing and analysis. In contrast, our approach closes-the-loop around observation and measurements, dynamically choosing the best sampling locations to maximally gain information and feeding models that can provide forecasts for incident responders. In addition, conceptual control strategies can ignore real-world issues affecting collection efficacy and often lack real-world empirical validation.

Sandia is also engaged in the development of novel sensor architectures that will enable future plume location and characterization. We have developed a class of silicon resonator sensors that are low SWaP, have a high-sampling frequency to enable thorough plume characterization, and sensitivity below 50 parts per billion for chemical agent surrogates. These sensors can be functionalized with polymer, sol-gel, or engineered metal-organic framework (MOF) collection films to provide class, and potentially, agent-level selectivity. These resonators are also being monolithically-integrated with micro gas chromatography (μGC) columns to produce low SWaP analysis systems capable of agent-level identification even in complex chemical backgrounds. The combination of the resonator and the μGC technology creates a sensor system capable of both rapidly locating and following a plume, as well as performing a rapid, low-false alarm rate, chemical identification.
Our future work is focused on the expansion of the physical architecture by integrating additional sensors (chemical and environmental) onto UAS platforms, expansion of UAS search and exploit capabilities through introduction of a UAS swarm-intranet that gathers and shares information from multiple locations simultaneously, and development of an air dispersion modelling framework that provides accurate source terms for model initiation and receives model output for flight path optimization.

SNL is managed and operated by NTESS under DOE NNSA contract DE-NA0003525