LOCALIZING CHEMICAL AND BIOLOGICAL THREAT DETECTION

Trace Aerosol Signature Detection And Classification Using Standoff Quantum Cascade Laser Absorption Spectroscopy: Preliminary Forward Modeling Results From The Iarpa Picard Program

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Aerosols are troublesome particles. Aerosols are known to cause respiratory illnesses, exacting a toll on human health and public health infrastructure. Aerosols can be deadly, particularly in the case of aerosolized opioids or chemical warfare agents. Aerosols impact the energy budget of the Earth, contributing to radiative forcing of the climate relative to preindustrial conditions. Aerosol sensing platforms are required to mitigate these hazards to human health and society, yet fieldable, trace aerosol sensing platforms remain elusive due to the complicated nature of aerosol phenomenology, namely that aerosol extinction spectra vary as a function of aerosol particle shape and size, aerosol analog variety, and aerosol conglomeration with ambient particles such as dust, pollen, bacteria or water. Complicating matters further, aerosols present dangers in trace concentrations, in dynamic, complex environments where more luminous, ambient sources compete against aerosol signatures for dynamic range of a sensing platform.

The IARPA PICARD program was stood up to develop fieldable sensing platforms for rapid standoff detection of harmful aerosols beyond the current state-of-the-art. In this work, we present our solution to the above problem set, specifically the design, build, and modeling of a state-of-the-art bistatic, quantum cascade laser absorption spectrometer capable of aerosol detection and classification by measurement of aerosol extinction spectra after reflection from a surface of opportunity. We call this new sensing platform the intelligent Chemical Aerosol Transmission Spectrometer (iCATS).

To support this effort, we developed rigorous, physics-based forward modeling tools for the iCATS sensing platform to model sensor subsystem performance, predict synthetic extinction spectra, calculate large libraries of synthetic extinction spectra for training detection and classification algorithms, and define detection limits as a function of optical design choices, sensing geometry, and aerosol phenomenology. We present the need for aerosol remote sensing in the CBD S&T community, how the iCATS sensing platform addresses that need, how we use forward modeling tools to emulate sensing data products and train models, how closely forward modeling predictions match experimental measurements collected with the iCATS prototype, and make predictions about what aerosols will be detectable at the end of the program.