AT A DISTANCE

SBIRs boost molecular chemical imaging technology, autonomously detecting hazardous materials in real time at standoff distances

It's a near universal problem. The smuggling of explosives, chemical weapons, and illegal drugs threatens public health and safety on a daily basis. Terrorists, both domestic and foreign, have targeted crowded areas with bombs hidden in vehicles or under clothing, causing unspeakable violence and destruction. Organizations like ISIS have used toxic chemical agents against Iraqi, Syrian, and U.S. military personnel, as well as local civilians. And the trafficking and abuse of illegal drugs in the U.S. has widespread negative consequences, including addiction, overdose deaths, crime, and the loss of productivity.

Real-time molecular chemical imaging (or hyperspectral imaging) technology can spot such concealed threats, seeing what the human eye cannot, capturing multiple images at tens to thousands of different wavelengths of light. Each pixel has an associated spectrum, or intensity value corresponding to each wavelength, that can then identify the substance at that location by its unique molecular fingerprint. Invented more than twenty-five years ago, molecular chemical imaging combines optical-based sensors with sophisticated algorithms to provide advanced visualization and actionable insights for a number of diverse applications.

In 2007, an Army Small Business Innovation Research (SBIR) contract with ChemImage Corporation, a company based in Pittsburgh, Pennsylvania, supported the development of the Real-Time Chemometrics and Sensor Fusion (RT-CSF) technology, which analyzes the incoming sensor data to perform autonomous explosives and chemical weapons detection. The effort focused on perfecting the software side of molecular chemical imaging in order to increase the probability of successful detection and lowering the rate of false positives.

"The RT-CSF program progressed from concept all the way to fielding of 20 systems to the U.S. military under a classified program that brought significant value to the warfighters," said Dr. Patrick Treado, Chief Technology Officer at ChemImage. "The SBIR also injected value into ChemImage from the perspective of teaching us all the things that we needed to do to support our end-users."

Treado founded ChemImage—originally known as ChemIcon—while working as an assistant professor at the University of Pittsburgh. He left academia to focus on developing ChemImage's technology platform, which has been applied broadly in the life sciences, semiconductor, food, pharmaceutical and polymer analysis. With anthrax emerging as a threat in 2001, ChemImage built up its biodefense capabilities in collaboration with the Armed Forces Institute of Pathology and the U.S. Army Edgewood Chemical Biological Center.

Over the years that followed, ChemImage worked closely with researchers at the Army Research Laboratory (ARL), whose ultimate goal was the development of instrumentation for standoff detection of explosive materials and IEDs. ChemImage's Phase I proposal for the 2007 Army SBIR topic for RT-CSF technology was selected, leading to Phase II, and follow-on Phase III contracts for the successful

A Threat Detector from ChemImage can screen passing vehicles for residues of hazardous materials.

ChemImage Internal Photo

development of the needed instrumentation.

"The Phase I and II SBIRs culminated in a program called LightGuard®, which became the best overall performing standoff detector for explosives detection in the U.S. Department of Defense arsenal," he said. "We spent lots of time at U.S. government field test sites to prove that this was the best overall technology, and then twenty of these systems were built, with a number of those fielded in Afghanistan and Kuwait."

LightGuard, a hyperspectral imaging detector about the size of a microwave oven, was developed to address specific explosive threat detection needs associated with IEDs. It was designed to sit mounted on a tripod at entry control points, where it could evaluate stationary incoming vehicles and people from distances that would not put troops in direct contact with a potential threat. A smaller version of LightGuard, could mount on a vehicle to scan on-the-move or stationary while detecting explosives on moving targets. The previous advances in software allowed for fully automated detection—a possible threat would trigger an audible alarm to alert the user, a bounding box on a monitor to show the location of the threat, and accurate identification of the material itself.

While LightGuard did not transition beyond rapid deployment to a program of record, the technology behind both the VeroVision® Threat Detector, which screens incoming vehicles at entry control points for residues of hazardous materials related to bomb making, and the VeroVision™ Mail Screener which scans inmate mail at correctional facilities for illicit substances, trace back to the initial RT-CSF technology that evolved under the Army SBIR. And recent work tied to a 2016 Phase I SBIR award from the Defense Advanced Research Projects Agency (DARPA) focused on building the next generation of smaller, faster, and more cost-effective imaging systems.

"What ChemImage set out to do under this effort was to use technologies that they had developed under other programs and augment that in order to provide the capability to use, for example, a handheld system or something that could be mountable on a small platform like an unmanned aerial vehicle, to do drug detection," said Whitney Mason, Program Manager for the DARPA project.

Mason and her colleagues connected the company with the Department of Homeland Security and the U.S. Army Edgewood Chemical Biological Center to perform extensive testing, anticipating real-world scenarios.

"The participants in these tests thought that this product was worthy of being considered for future efforts," said Mason. "So, from my perspective, it was hugely successful."

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Since the completion of the DARPA project, evolution of the handheld sensor has progressed, and Treado hopes to bring the product to market soon, along with another miniaturized device for a different purpose: medical imaging.

ChemImage's CardioVere®, currently in late-stage clinical trials, is being commercialized as the only handheld, non-invasive, non-contact device to monitor congestion in heart failure patients in all care settings, including the home. The device leverages the molecular chemical imaging technology to find early signs of tissue congestion, indicating that a heart failure patient's heart is not working efficiently.

"The root of a lot of what we are doing, circling back to the original intent of the company, is in medical imaging. These technologies are being used in a number of settings, including heart failure monitoring," said Treado. "CardioVere and all the VeroVision platforms flow from LightGuard, which itself flows from that original SBIR from the Army."

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