INNOVATIONS IN NEXT GENERATION CB THREAT CHARACTERIZATION AND ASSESSMENT FOR DECISION SUPPORT

Microfluidic Innovations To Enable Sensitive And Multiplexed Nucleic Acid Detection In The Field

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Sensitive and multiplexed detection of nucleic acid targets from biological samples is a challenging problem which is typically addressed using specialized equipment in a laboratory setting. The process involves several key steps including sample collection, sample lysis, nucleic acid extraction, nucleic acid detection, and signal readout. Each of these steps is often achieved using separate pieces of equipment, specialized processing kits, or a sequence of manual steps which require user intervention. For these reasons, the existing process is not suitable for in-field use.

To address this need Draper is developing a fieldable sample-to-answer system for nucleic acid detection, as part of an MRIGlobal-led team. The Massively Multiplexed Detection (MMD) device will provide an all-in-one solution for highly-multiplexed detection (1,000 or more nucleic acid targets) in an automated, battery-powered, and shelf-stable platform. In this presentation we will highlight two innovations which will enable device performance: The integration and optimization of a nucleic acid extraction column in a microfluidic network will provide high nucleic acid yield and a unique approach to microfluidic mixing will enhance the transport of extracted nucleic acids in the assay chamber.

The first component of the MMD device we will highlight is the Automated Sample Preparation module. This module accepts unprocessed biological samples, including nasopharyngeal swabs and bronchoalveolar lavage fluid, and provides extracted nucleic acids to downstream components in the device. The module comprises a microfluidic network, with passive (e.g., nucleic acid extraction column, check valves) and active (e.g., syringe pump, selector valve, heater) components. The active components are computer-controlled and are operated in an automated fashion following a predefined series of processing steps. These steps have been optimized to provide high nucleic acid yield from unprocessed samples. We will present data to confirm performance which is on par with what can be achieved using state-of-the-art benchtop techniques.

The next component we will discuss is the Microfluidic Mixing module which handles the transport of extracted nucleic acids eluted from the Automated Sample Preparation module to the assay array and stirs the sample to increase the likelihood of detection. One key feature of the module is a custom-designed microfluidic chamber which is mechanically coupled to a vibration motor and which incorporates several air-filled cavities. The vibration motor causes deflection of the top surface of the chamber which leads to motion of the fluid and mixing throughout the closed volume. The air-filled cavities enhance mixing by locally amplifying mechanical excitation from the motor. We will present data from experiments in which we use the system to mix fluorescein dye and measure the fluorescence uniformity across the chamber over time to assess mixing efficacy.

The MMD device will provide an unprecedented capability in enabling sensitive and highly multiplexed nucleic acid detection from raw input sample in a portable form factor. In this presentation we will share our recent progress and results from our development of the Automated Sample Preparation and Microfluidic Mixing portions of the device.

The authors would like to acknowledge important contributions from Draper team members Jonathan Crocker, Jason Fiering, John Julias, Kimberly Kelly, Ernest Kim, Stacey Markovic, Alket Mërtiri, Isaac Moran, Logan Rubio, Ruben Torres-Sanchez, and Michael Turo and program support from Brandon Basso, Charlene Charles, Rick Crocker, Karen Arenburg, and the Draper machine shop. The authors also thank Julie Lucas and Richard Winegar from MRIGlobal for helpful conversations. The authors acknowledge support from the DARPA Biological Technologies Office as part of the Detect It with Gene Editing Technologies (DIGET) program funded under the Naval Information Warfare Center contract N66001-21-1-4048 which is awarded to MRIGlobal (prime). Draper is executing work under subcontract 811-111161 -2.