LOCALIZING CHEMICAL AND BIOLOGICAL THREAT DETECTION

Exploratory Analysis Of Multi-sensor Wearables Data On Chemical Exposure

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Exposure to harmful chemical agents threatens Warfighter health, but early warning of these exposures can be challenging since the agents may not be overtly perceptible to the human senses. Previous studies have demonstrated promising capabilities for early warning of biological exposures (e.g. SARS-CoV-2 and influenza) based on physiological measurements obtained from wearable devices. While chemical exposures are also likely to induce a measurable physiological response, it may manifest in seconds to minutes and hence algorithms developed for early warning of biological exposures are unlikely to generalize to chemical exposures. Previous studies of electrocardiogram (ECG) measurements on animals exposed to fentanyl and nerve agent (Vx) shows promise for detecting physiological changes induced by the exposure with >81% accuracy. Our current study aims to improve understanding of the human physiological response to chemical exposures and quantify/predict those responses using wearable sensing technologies to identify early warning indicators of potentially harmful chemical exposures.

This work highlights exploratory data analysis of two multi-modal datasets on humans. Our analysis aims to 1) understand the correlation between features and chemical proxy events and 2) characterize notable differences in the measured data across devices including resolution and measurement noise. The first dataset is from a DTRA funded study that included a total of 39 marines that participated in the Chemical Biological Incident Response Force's (CBIRF) basic operating course (CBOC) while wearing up to 2 photoplethysmogram (PPG) devices and an ECG patch. During the course, the Marines were exposed to CS gas and a paired sham exposure with an inert gas. In addition, standard personal information (e.g., sex, age, skin tone) for the participants and hourly schedule information regarding activity/stress level was collected to identify confounders and trends. The second dataset was conducted by Philips under DTRA funding and included a total of 83 participants dosed with opioids while wearing up to 6 devices (e.g. ECG, PPG, continuous glucose monitor, and blood pressure monitors) for 24 hours and standard personal information.

Exploratory data analysis of the CBIRF and Philips dataset demonstrated the ability to distinguish between outliers and data that may be important in detecting a chemical exposure, leverage probability distributions for greater analytical efficiency, and use dimensionality reduction methods (e.g., principal component analysis (PCA) and Uniform Manifold Approximation and Projection (UMAP)) to determine feature importance and compare the quality of the information obtained from each type of wearable device. For example, preliminary results demonstrate that PCA has great potential for feature engineering and that four principal components are typically able to capture at least 95% of the variability within the wearable data for CS gas exposures. We also found that using multiple baselines (e.g., hourly, daily) can tease out critical information within the data when used with anomaly detection methods such as Mahalanobis distance.

This material is based upon work supported by the Under Secretary of Defense for Research and Engineering under Air Force Contract No. FA8702-15-D-0001. Any opinions, findings, conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the Under Secretary of Defense for Research and Engineering.