LOCALIZING CHEMICAL AND BIOLOGICAL THREAT DETECTION

Lightweight Wearables-based Algorithms For Detecting Exposure To Chemical, Biological, And Environmental Threats

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Background. Wearables have become increasingly popular for measuring general health and physical fitness. Raw data collected through integrated sensors (e.g., accelerometers and optical sensors) are converted into health metrics such as step counts and heartrate. Health metrics are further combined into scores that communicate information like “readiness” using proprietary algorithms. Platforms acquire these data by querying the wearables’ vendor cloud where data are stored, and complex calculations run. Purpose. Wearables provides a mechanism for monitoring Soldier health and safety. To be of use, threat detection models need to operate in resource-limited (e.g., no internet) settings and as close to the end user as possible. The models must also accommodate use of different wearables and evolve based on the source of the threat. Objective. Design lightweight processing routines, algorithms, and models that can run on edge computing devices to monitor Soldier health. Use minimally processed data from wearables to reduce vendor lock and maximize flexibility. Rationale. Models that use health scores derived from vendor algorithms inherently rely on an internet connection to send/receive data from the vendor cloud. This introduces a lag in processing and jeopardizes security. Additionally, these models must be re-trained for different wearables and even firmware updates from the same vendor that significantly change results. Methods. The Architecture for Localized Precision Health data Acquisition from Wearables (AlphaWear) acquires the least processed form of data available directly from the wearable. Methods implemented on the AlphaWear software stack clean the data to remove out-of-range values and other sources of artifact, as well as align the signals to common windows. Base health metrics are extracted using published methods and Government-owned algorithms (e.g., ECTempTM). The base health metrics are standardized to remove known sources of variation both within (e.g., from physical activity or time-of-day) and between individuals by matching the current data point to a similar timepoint in the recent past. Anomaly detection is used to identify events in the standardized data, and a logic layer identifies if the detected event is consistent with a response to a physiologically stressful event such as illness. Results. We have demonstrated wearables data processing, base metrics extraction, and standardization routines with Garmin smartwatches, the Oura ring, and the Samsung Galaxy Watch 3 through the DARPA SIGMA+, JPEO-CBRND Wearables Pilot, and DTRA MTEC-22-10-ChemBio-009 efforts. We have implemented several algorithms (e.g., SIGMA+ Health, PRESAGED, and ECTempTM) using the calculated base and standardized metrics. We simulated data processing for 150 users with 1-week of data (~450k raw readings per user). The base metric calculations required 1 CPU and 0.05 GB RAM. The SIGMA+ Health algorithm required 2 CPU’s and 0.2 GB RAM. Conclusions & Impact. We have designed, implemented, and demonstrated lightweight wearables data processing and analysis routines using the AlphaWear platform that are appropriate for edge computing devices. The methods are flexible and can accommodate data from different wearables as well as adapt to detect different types of chemical, biological, and environmental threats. Next steps involve testing and validating the algorithms.

We would like to acknowledge the JPEO-CBRND Wearables Pilot program for funding. We would like to thank Bryan Rivers and Loren Hankla for stimulating conversation related to the AlphaWear platform.