HARNESSING PHYSIOLOGICAL DATA FOR EARLY WARNING OF THREAT EXPOSURE

Real-time Cbrn Algorithms Using Smartwatch Data

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Background
Quickly identifying individuals exposed to biological agents is critical for initiating treatment and reducing spread if the agent is contagious. Smartwatches are convenient for acquiring health data, but accuracy is compromised compared to gold standard sensors such as electrocardiograms (ECGs), making it difficult to translate models developed with clinically acquired data into the field. RTI International bridged this gap by using a wearable ECG sensor to collect high resolution heart rate (HR) and activity data during an influenza challenge study conducted under the DARPA SIGMA+ program. This analysis framework was translated to work with data acquired using Garmin smartwatches.

Methodology
Hardware-specific data cleaning routines were implemented to remove artifacts from the data resulting from motion artifact and other sources of noise. Data were binned to 5-min windows and metrics related to activity, HR, HR variability, SpO2, and respiration rate extracted using open-source tools. These metrics are meant to be generic so they can be used by several algorithms.
Metrics were placed into a rolling buffer with a timestamp. The current point was compared to healthy data in this buffer from a similar physiological state. For real-time implementation, a short gap was introduced to ensure that the baseline was not contaminated by unhealthy data. For illness prediction, activity level and time of day were used for standardization.

The standardized metrics feed a health model that used statistical approaches to determine deviations from the baseline distribution in multidimensional space. If the deviation exceeded a threshold, a health alert was issued. The threshold can be adjusted to balance false positives and negatives, prediction timing, etc.

Results
The flu challenge study allowed us to (1) identify asymptomatic individuals and (2) precisely lock the timing of exposure versus relying on symptom reports. Our best performing algorithm identified 16/17 positive individuals (majority before symptom onset) with no false positives (i.e., in the 1-week of non-exposed data from 17 individuals and full datasets from the 3 individuals who tested negative).
The SIGMA+ Health algorithm has additionally been demonstrated at several exercises sponsored by the Joint Program Executive Office for Chemical, Biological, Radiological, and Nuclear Defense and evaluated with other datasets (i.e., SIGMA+ and Defense Science and Technology Laboratory cohorts) that were generated using Garmin Fenix 6 smartwatches. Feedback from users related to wearables and their utility was positive. Results from these efforts informed improvements to the original algorithm to accommodate events such as recovery from exercise, outdoor work for extended periods, and inconsistent wear.

Impact
A key differentiator of the SIGMA+ Health algorithm is the ability to continuously provide a risk prediction by compensating for normal physiological differences due to time of day and activity. This is accomplished by standardizing to healthy “baseline” data filtered to a similar physiological state. Not only does standardization correct for normal, within-person variation, but it eliminates between-person differences and places everyone (and all metrics) on the same scale. The framework for continuous risk prediction is translatable to any sensor that can acquire the necessary high resolution HR data.

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