TODAY'S INNOVATION, TOMORROW'S WARFIGHTER CAPABILITIES

Wearable Physiological Monitoring Technologies for Earlier Warning of Health Changes

Pre-symptomatic Detection from Wearable Physiological Sensors as Early Warning and Decision Support Tool

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We describe a solution for warfighter protection and biosurveillance of groups by predicting upcoming pathophysiological changes to allow timely intervention. This methodology relies on continuous analysis of data from a noninvasive physiological sensor and provides early indications of adverse health effects when autonomic parameter thresholds are exceeded. Data is extracted from a COTS sensor on active subjects without requiring interruption to normal activity. The detection principle is measurement of the innate immune response which is engaged after injury but well before visible indications of illness. This immune response is regulated by the autonomic nervous system which can be dynamically monitored through the brain-heart connection reflected in heart rate variability (HRV) measures. HRV has been shown to be predictive of health outcomes and an early biomarker of infection in retrospective studies. Traditionally, multi-day HRV comparisons are done by evaluating subjects at a specific time of day under controlled conditions (e.g., after sitting still for 30 minutes). A particular challenge for the early warning application and addressed by our approach is the analysis of HRV metrics from active subjects without any foreknowledge of activity state. This biosurveillance application is enabled by RTI's algorithm for real-time extraction of the heart rate and HRV that outperforms traditional methods in active subjects, and eliminates the need for manual signal correction. The algorithm was assessed on 6 subjects performing a variety of activities. The ECG peak detection algorithm achieved an error rate that was nearly 3 times less than traditional methods.

For wearable technologies to be used as in support of a biosurveillance application, continuous monitoring and multiday data comparison is required. Commercially available ECG sensors lack the processing capability and/or battery life to meet the requirements of continuous monitoring for threat exposure over many days. We have demonstrated an embedded microprocessor platform that enables power-efficient data collection and processing for obtaining warning in real time. The peak detection and HRV computation algorithm was implemented on a microcontroller and processed streamed ECG data in near real time with only a short delay (4 seconds) for peak verification and correction. Across a range of activities, HRV values were within 2% of the values obtained from the gold standard manual peak identification. The sensor and microprocessor can be configured for battery-conserving operation in which monitoring is continuous, but raw sensor data is condensed and transferred to the decision engine only at specified intervals.

We will demonstrate that the approach can detect changes in health by recording physiological data from healthy human volunteers exposed to low-dose endotoxin inhalation challenge. This inhalation challenge provides a reproducible, transient innate immune response similar to early stages of infection without overt clinical symptoms such as fever.

This technology will provide warning of illness hours to days prior to the onset of clinical symptoms and is designed for passive, long-term monitoring of individuals or groups.