## HARNESSING PHYSIOLOGICAL DATA FOR EARLY WARNING OF THREAT EXPOSURE

# Monitoring Exposure Through Standoff Health

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Background/Purpose:
Respiratory rate (RR) and skin temperature have been found to be among the top predictors of exposure to infectious agents. In some work situations, such as US military operations, the use of wearable devices for monitoring of vitals might be limited, cumbersome or unsafe. A major fundamental question is whether informative vital signs can be remotely measured at distance with sufficient accuracy to enable early-warning for health threats that could affect force readiness.

Objective:
The Philips Monitoring Exposure through Standoff Health (MESH) team, on a grant from the Defense Threat Reduction Agency (DTRA), performed a trade study that evaluates multiple contactless modalities for measuring RR and temperature under a variety of conditions across a set of increasing long-range distances. We leveraged existing Philips contactless monitoring solutions and experience and investigated integrating inference across modalities to assess the potential for improving performance and robustness.

Methods:
We performed two sets of experiments. The first used a physical phantom simulation with two metal panels attached to its chest, each powered by a servo motor, controlled by an Arduino board. This system allowed for chest to resemble respiratory motion. In addition, the phantom was equipped with speakers to simulate breathing sounds, and could be warmed to simulate physiological body temperature. The second set of experiments was performed on retrospective data from three human volunteers.
For RR estimation, we used two inexpensive common-off-the-shelf visible light cameras, laser rangefinders for measurement of chest excursion, and a parabolic microphone for recording of breathing sounds. We performed phantom experiments at 20, 50, 83 m and human experiments at 20, 45 and 100 m. Recording conditions we explored included different clothing, body positions, and lighting. We fused the data collected from different modalities using a weighted average approach in the spectral domain, where the weight was based on a Signal Quality Index.
The ground truth measurement for respiratory rate was provided with a Zephyr chest strap.
For temperature estimation, we utilized a thermal camera and a higher end thermal sensor. We ran experiments at 5, 10 and 20 m (plus 45 and 100 m for the thermal sensor) with the subjects wearing combinations of a hat and sunglasses. We used a reference object of known temperature for calibration and we mapped pixel intensity values to temperature values. The ground truth measurement temperature was provided with a contactless forehead thermometer.

Results:
We found that the camera-based approach was accurate for RR detection at up to 100 m, with errors less than 3 bpm in humans. Fusion with microphone estimates further improved performance in some cases, while rangefinder-based estimates did not.
Temperature estimates using the thermal camera had average errors

Conclusion:
This is an exploratory study with a limited dataset, but results are promising and show potential for physiological monitoring at range in military applications.

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