SPECKLEPLETHYSMOGRAPHIC (SPG) ESTIMATION OF HEART RATE VARIABILITY

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Heart rate variability (HRV), a class of metrics derived from variability in R-R intervals typically measured using electrocardiography (ECG), has implications for cardiovascular and neurological health[1]. Recently, HRV was used to track the recovery of athletes after exercise training due to its ability to noninvasively monitor the autonomic nervous system (ANS)[2]. Exercise training generally has a positive impact on the ANS by reducing resting heart rate and increasing cardiac vagal tone at rest[3]. However, overexertion from excessive workout sessions can counteract the benefits of regular exercise and reduce HRV[4].

Unfortunately, routine, remote ECG HRV monitoring is limited due to portability, cost, and loss of accuracy. Various groups have attempted to address the limitations of ECG monitored HRV by estimating HRV with simpler photoplethysmography (PPG) technology[5]. Transmittance PPG, the signal used in pulse oximetry, measures changes in intensity due to light absorption caused by the dilation and constriction of arteries and arterioles in the finger due to pulsatile blood flow. Alas, HRV approximated from PPG finger measurements loses accuracy due to significant peak time delays related to various factors such as arterial stiffness, vascular tone, and height[6].

Speckleplethysmography (SPG), a coherent optical signal that measures changes in blood flow using laser speckle imaging, is an inexpensive, early-stage technology, not yet tested for HRV, that has a higher signal-to-noise ratio[7] and robustness in the presence of motion artifact and cold temperatures, when compared to PPG[8]. In addition, the SPG waveform peaks before the PPG waveform, which should improve accuracy and reduce the impact of vascular compliance on HRV estimation.

Given the aforementioned benefits of SPG, we studied the relationship of SPG and PPG to ECG for estimation of HRV during an orthostatic challenge performed by 17 subjects. We found that SPG estimations of HRV are highly correlated to ECG HRV for both time and frequency domain parameters (Fig. 1) and provide improvements over PPG estimations of HRV. For 11 out of 12 HRV parameters, the correlation coefficients for SPG and ECG are greater than the correlation coefficients for PPG and ECG. The results suggest SPG measurements are a viable alternative for HRV estimation when ECG measurements are impractical.

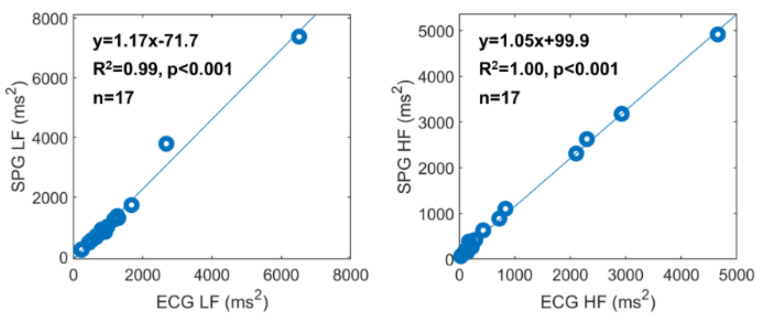

Figure 1 – SPG and ECG data collected from 17 subjects while standing. Waveforms were bandpass filtered to extract low-frequency (LF) and high-frequency (HF) contributions to the waveforms. The data show a strong correlation.

The two most relevant topics for the abstract are Imaging through Turbid Media and Optics and Biomechanics. The information is relevant to the conference because it provides a new translational application of a photonic technology, with *in vivo* results for the SPG technique.

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