

Pilot Study on Electrocardiogram Derived Respiratory Rate using a Wearable Armband

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A pilot study on deriving respiratory rate from electrocardiogram (ECG) signals recorded by a self-developed wearable armband is presented. The armband is designed to be worn on the left arm. It includes a pair of dry electrodes which record ECG. The dry electrodes and the locations of the electrodes in the arm is neither the optimal option for obtaining the best ECG signals nor for exploiting the influence of respiration over the ECG. However, it is more viable option than the conventional setup based on wet electrodes over the chest. The use of dry electrodes allows the long-term monitoring because they do not cause skin irritation while the conventional wet electrodes do, and placing the electrodes over the arm is more convenient and practical. Nevertheless, this represents a more challenging scenario than using wet electrodes over the chest because the signal-to-noise ratio is lower with dry electrodes. Moreover, the respiration-synchronous movement of the electrodes with respect to the heart is reduced when electrodes are placed over the arm. In this way, the respiration-related modulation in the ECG morphology may rely mainly on the impedance changes in the chest due to the airflow exchange.



Armband location

Armband-ECG and plethysmography-respiration signals were simultaneously recorded from 5 subjects (3 male) while paced breathing at constant rates from 0.1 to 0.4 Hz (with an increment of 0.1 Hz). Respiratory rate was estimated from the armband-ECG by using a method available in the literature, based on the variations in QRS slopes and R-wave angle. The estimations were compared to those obtained from the respiration signal. Obtained median and interquartile ranges of the relative error were lower than 4% for every requested respiratory rate. This suggest that normal ranges of spontaneous respiratory rate could be estimated from the wearable armband, allowing us to consider it for long-term wearable cardio and/or respiratory monitoring.

Obtained median (Med) and IQR of relative error for each respiratory rate.

Rate	0.1 Hz	0.2 Hz	0.3 Hz	0.4 Hz
Med (%)	0.85	-0.19	-0.07	-0.18
IQR (%)	2.31	0.69	0.35	1.80