# Abstract

Cardiac disorder is one of the major risk factors for human mortality. Continuous monitoring and assessment of cardiac mechanics are most important to reduce the risk factors of cardiovascular diseases and death rates. Seismocardiogram (SCG) is the manifestation of thoracic vibrations induced by cardiac movements. It is measured non-invasively on the chest-wall. This helps in diagnosing and monitoring cardiac mechanical activities. Proper diagnosis of cardiac pathology using this signal needs precise signal characterization, delineation, and feature extraction. Delineation facilitates the estimation of SCG fiducial points corresponding to cardiac events. In this study, the fiducial points of the SCG signal are estimated, and their applications are investigated. These may be helpful for personalized healthcare, telemonitoring, and wireless body area networks. Delineation of SCG waveform is investigated under the categories of standalone and other cardiac-signal assisted approaches. Two different standalone approaches are developed based on time-frequency analysis of the SCG signal. These methods mainly estimate the prominent peaks of SCG cycles that due to aortic valve opening (AO). The first method is based on data-independent multiscale decomposition. In the second method, data-adaptive variational mode decomposition (VMD) is modified, providing an optimal combination of input parameters ($\alpha$, $K$). Results suggest that the modified VMD based method performs better. With the assistance of electrocardiogram (ECG) signal, orthogonal subspace projection-based a new delineation framework is developed. It can efficiently estimate two fiducial points, AO and post-AC peaks from SCG systole and diastole profiles, respectively. To extract more fiducial points, the scalographic-photoplethysmogram (PPG) assisted SCG delineation algorithm is proposed. This algorithm can extract six fiducial parameters, simultaneously. More specifically, three fiducial points are estimated from each of both profiles, and a better characterization of the systole and diastole profiles is made possible with them.

Being a cardiac mechanical signal, the SCG is employed to derive the fundamental heart sounds (HS) and to characterize them as an application. The developed HS extraction method is mainly based on multiscale decomposition and center-of-gravity criterion. Another application is explored, which relates to the extraction of morphological variability in the SCG cycles. These morphological variations can be utilized to analyze the SCG affecting factors, including body movement, posture, and breathing pattern. In this study, the effect of respiratory-effort levels on to the SCG signal is analyzed. Results suggest that the SCG morphology changes with varying lung volume due to various breathing states, such as breathlessness, normal breathing, and long and labored breathing. A method is deployed, where the morphological changes are quantified by extracted hybrid features, including fiducial and non-fiducial features. The assistance of ECG signals is taken into consideration for this method. Under this method, the SCG signals are classified into different respiratory-effort levels using stacked-autoencoder based classifier. Performance results are also compared with other well-known classifiers. The robustness of the proposed methods is evaluated using SCG signals from publically available database and in-house recordings. For creating an SCG database, a small electronic circuit board is designed, which consists of a 3-D MEMS-based accelerometer, pre-amplifier, and filter. It is interfaced with a standard data acquisition system to record SCG signals.

KEYWORDS: Seismocardiogram, Variational mode decomposition, AO peaks, Delineation, Stacked autoencoder, Scalogram, Cardiac activity