Discrete Wavelet-Aided Delineation of PCG Signal Events via Analysis of an Area Curve Length-Based Decision Statistic

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The aim of this study is to describe a new false-alarm probability (FAP) bounded unified framework for segmentation of the phonocardiogram (PCG) signal sounds registered by an electronic stethoscope board. To meet this end, first the original PCG signal is pre-processed by application of an appropriate bandpass finite-duration impulse response (FIR) filter and then by implementation of a trous discrete wavelet transform (DWT) to the filtered signal for extracting several dyadic scales. Then, after choosing a proper scale, a fixed sample size sliding window is moved on the selected scale and in each slid, the area under the excerpted segment is multiplied by its curve-length to generate the Area Curve Length (ACL) metric to be used as the segmentation decision statistic (DS). Next, using an adaptive smoothing filter (ASF), the obtained metric is modulated and is freed from the fast fluctuations occurring in the vicinity of the events onset and offset locations which consequently results enhancement of edges detection accuracy. Afterwards, histogram parameters of the filtered DS metric are used to regulate the -level Neyman-Pearson classifier for FAP-bounded delineation of the PCG events. To assess performance quality of the proposed PCG segmentation algorithm, the method was applied to all 85 records of Nursing Student Heart Sounds database (NSHSDB) including stenosis, insufficiency, regurgitation, gallop, septal defect, split sound, rumble, murmur, clicks, friction rub and snap disorders with different sampling frequencies. Also, the method was applied to the records obtained from an electronic stethoscope board designed for fulfillment of this study in the presence of high-level power-line noise and external disturbing sounds and as the results, no false positive (FP) or false negative (FN) errors were detected. High robustness against measurement noises of the electronic stethoscopes, acceptable detection-segmentation accuracy of PCG events in the presence of severe heart valvular and arrhythmic dysfunctions within a tolerable computational burden (processing time) and having no parameters dependency to the acquisition sampling frequency can be mentioned as the important merits and capabilities of the proposed ACL-based PCG events detection-segmentation algorithm.