Toney Sebastian, Wavelet based denoising of ECG and ICG signals, M. Tech. Thesis, Department of Biosciences and Bioengineering, Indian Institute of Technology Bombay, June 2011.

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Abstract: The electrocardiogram (ECG) and impedance cardiogram (ICG) are biosignals related to the functioning of the heart. Impedance cardiography is based on sensing the variation in the thoracic impedance caused by variation in the blood volume in the thorax. The respiratory and motion artifacts in the sensed signal introduce errors in the estimation of the stroke volume and other cardiovascular indices. A wavelet-based denoising technique, using discrete Meyer and symlet-26 wavelets, for suppressing these artifacts was investigated. It uses scale-dependent thresholding for suppressing the respiratory artifact and limiting of the wavelet coefficients for suppressing the motion artifact. Denoising of ICG signals with simulated respiratory artifacts of -9 dB resulted in an SAR improvement of 23.5 dB, and L_2 norm and max-min based improvement indices close to one. Denoising of ICG recordings with actual artifacts resulted in improvement indices of value close to one, indicating that artifacts were suppressed without introducing any significant distortion in the signal. Wavelet-based denoising was also investigated for suppressing the EMG noise and the motion artifact in ambulatory ECG. EMG noise is reduced by thresholding the wavelet coefficients using an improved thresholding function combining the features of hard and soft thresholding. Motion artifact is reduced by limiting the wavelet coefficients. Thresholds for both the denoising steps are estimated using the statistics of the noisy signal. Denoising of simulated noisy ECG signals with -10 dB input SNR resulted in an average SNR improvement of 11.4 dB, and its application on ambulatory ECG recordings resulted in L_2 norm and max-min based improvement indices close to one, indicating that the technique was effective in denoising without introducing any significant signal distortion. Its application significantly improved automated R-peak detection.