T. Pranava, Wavelet based denoising of ECG signals, M. Tech. Thesis, Department of Biosciences and Bioengineering, Indian Institute of Technology Bombay, June 2012.

Supervisor(s): Prof. P. C. Pandey

Abstract: Electrocardiography is an important non-invasive diagnostic tool for identifying cardiac disorders. It is usually prone to noise and artifacts. Wavelet based denoising techniques, using discrete Meyer wavelet function, were investigated for EMG and motion artifact suppression in ECG, and the use of translation-invariant wavelet denoising and stationary wavelet transform based denoising were investigated for suppressing the effect of Gibbs phenomenon introduced by discrete wavelet transform based denoising. EMG noise is suppressed using level-dependent thresholding and motion artifact is suppressed using coefficient clipping technique. The technique resulted in efficient denoising with no significant distortions introduced. SNR improvement, percentage RMS difference, L2 norm and MaxMin based improvement indices, and R-peak detection efficiency were used for quantitative evaluation. Artifact-free ECG signals from MIT-BIH arrhythmia database and ECG-free artifacts from MIT-BIH noise stress test database were used to generate simulated noisy signals with known SNR. For an input SNR of -10 dB, the SNR improvement of 14.5, 15.0 and 14.7 dB were obtained for DWT, TIWT and SWT based denoising, respectively. A correlation coefficient value of 0.99 was observed between denoised ECG and artifact-free ECG signals, indicating insignificant distortion of noise-free signals. An improvement in QRS detection efficiency from 94.4 % to 99.3 % with reduction in false detection percentage from 21.2 % to 14.9 % was obtained. The denoising techniques were also validated for ambulatory ECG signals from normal subjects and patients with cardiac abnormality available at MIT-BIH ECG databases and sudden cardiac death database. Significant improvement in QRS detection efficiency from 63.2 % to 90.6 % with reduction in false detection percentage from 0.1 % to 0.05 % was obtained. A software application "ECG Denoiser, v.2" has been developed incorporating DWT based ECG denoising for artifact suppression in 3-lead ECG signals acquired from Holter monitor with a sampling frequency of 200 Hz using LabWindows.