Approximation of ECG Signals using Chebyshev Polynomials

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Abstract

The ECG (Electrocardiogram) signal represents electrical activity of heart and are recorded for monitoring and diagnostic purpose. These signals are corrupted by artifacts during acquisition and transmission predominantly by high frequency noise due to powerline interference, electrode movements, etc. Addition of these noise change the amplitude and shape of the ECG signal which affect accurate analysis and hence need to be removed for better clinical evaluation

In this paper, ECG signal taken from MIT-BIH database is first denoised using Total-Variation Denoising (TVD); see Rudin et al. (1992) using Majorization-minimization (MM) optimization technique. TVD is based on the principle that signals with excessive and spurious details have high variation. The performance of the denoised signal is measured by Correlation Coefficient (CC), Root-Mean Square Error (RMSE) and signal to noise ratio (SNR), where a significant change in signal to noise ratio is observed while the visual appearance is retained.

ECG signals generate massive volume of digital data, so they need to be suitably compressed for efficient transmission and storage. Hence, for efficient compression the signal is segmented into various sections using bottom-up approach. Bottom-up approach is an iterative approach, which begins by dividing the original signal into small segments of equal lengths and then successively merged into bigger segments based on the least square error between the pairs.

The individual sections are then approximated using Chebyshev polynomials of suitable orders. The performance of the approximation technique is measured by computing the maximum absolute error and the compression ratio. The results are also compared with other techniques as reported in the literature, where a significant improvement in the compression ratio is observed.

References

Rudin, L. and Osher, S. and Fatemi, E. Nonlinear total variation based noise removal algorithms. *Physica D*, 60:259–268, 1992.