Denoising Performance of Discrete Wavelet Transform and Empirical Mode Decomposition Based Techniques on Monitoring Cardiac Electrograms from the Left-Arm

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Introduction

Currently available cardiac monitoring provides mostly information about the heart rate; however, these cannot continuously capture atrial and other ECG heart rhythm attributes. This study evaluates the performance of three denoising approaches as first step for developing clinical relevant algorithm. Denoising techniques are useful for enhancing the quality of cardiac electrograms recorded from bipolar leads on the left arm, thus being the case of far-field monitoring of the electrical activity of the heart and rhythm features.

Methods

An arm surface potential mapping clinical dataset was developed and used retrospectively for this study. The study arm-ECG dataset consisted of 58 left-arm ECG bipolar leads. The denoising methods considered were the Daubechies, order 10 (Db10), discrete wavelet transform (DWT), the discrete Meyer (Dmey) wavelet transform, and Empirical Mode Decomposition (EMD). Performance evaluation is quantified by measurements of the signal-to-noise ratio (SNR) and using the conventional method of ECG noise reduction by ECG signal averaging (SA) technique, as the golden standard performance control method.

Results

The performance results on two bipolar left-arm ECG leads: Lead-1 (on the upper-arm, transversally) and Lead-4 (axially, along the upper-arm), yielded SNR (mean +/- SD) values for Dmey, Db10, EMD and SA of: 11.8 ±9.9; 13.9 ±15.2; 17.9 ±13.5; and 98.9 ±118.6, respectively, for Lead-1. On Lead-4, the SNR performance results were: Dmey (6.12 ±4.6), Db10 (6.29 ±4.5), EMD (11.2 ±14.2) and SA (45.1 ±40.9).

Conclusions

The study revealed that the EMD based denoising technique offered the best performance on both upper-arm ECG leads; and the two DWT based techniques performed similarly between the two wavelet types (Db10 and Dmey), in their ECG denoising ability.