ECG Parametric Modeling Based on Signal Dependent Orthogonal Transform

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Abstract

In this letter, we propose a parametric modeling technique for the electrocardiogram (ECG) signal based on signal dependent orthogonal transform. The technique involves the mapping of the ECG heartbeats into the singular values (SV) domain using the left singular vectors matrix of the impulse response matrix of the LPC filter. The resulting spectral coefficients vector would be concentrated, leading to an approximation to a sum of exponentially damped sinusoids (EDS). A two-stage procedure is then used to estimate the model parameters. The Prony's method is first employed to obtain initial estimates of the model, while the Levenberg-Marquardt (LM) method is then applied to solve the non-linear least-square optimization problem. The ECG signal is reconstructed using the EDS parameters and the linear prediction coefficients via the inverse transform. The merit of the proposed modeling technique is illustrated on the clinical data collected from the MIT-BIH database including all the arrhythmias classes that are recommended by the Association for the Advancement of Medical Instrumentation (AAMI). For all the tested ECG heartbeats, the average values of the percent root mean square difference (PRDs) between the actual and the reconstructed signals were relatively low, varying between a minimum of 3.1545% for Premature Ventricular Contractions (PVC) class and a maximum of 10.8152% for Nodal Escape (NE) class.

Keywords: Electrocardiography, Transforms, Heartbeat, Vectors, Computational modeling, Biological system modeling, Parametric statistics

DOI: 10.1109/LSP.2014.2332425
Journal of IEEE Signal Processing Letters

Published by: IEEE, On 2014/7/2