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An Improved Total Variation Regularization Method for Denoising Magnetocardiography

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Abstract : The application of magnetocardiography signals to detect cardiac electrical function is a new technology developed in recent years. The magnetocardiography signal is detected with Superconducting Quantum Interference Devices (SQUID) and has considerable advantages over electrocardiography (ECG). It is difficult to extract Magnetocardiography (MCG) signal which is buried in the noise, which is a critical issue to be resolved in cardiac monitoring system and MCG applications. In order to remove the severe background noise, the Total Variation (TV) regularization method is proposed to denoise MCG signal. The approach transforms the denoising problem into a minimization optimization problem and the Majorization-minimization algorithm is applied to iteratively solve the minimization problem. However, traditional TV regularization method tends to cause step effect and lacks constraint adaptability. In this paper, an improved TV regularization method for denoising MCG signal is proposed to improve the denoising precision. The improvement of this method is mainly divided into three parts. First, high-order TV is applied to reduce the step effect, and the corresponding second derivative matrix is used to substitute the first order. Then, the positions of the non-zero elements in the second order derivative matrix are determined based on the peak positions that are detected by the detection window. Finally, adaptive constraint parameters are defined to eliminate noises and preserve signal peak characteristics. Theoretical analysis and experimental results show that this algorithm can effectively improve the output signal-to-noise ratio and has superior performance.

Keywords : constraint parameters, derivative matrix, magnetocardiography, regular term, total variation
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