CHAPTER 7

CONCLUSION AND FUTURE WORK

7.1 INTRODUCTION

In this research work, improved EMD based algorithms are proposed to remove baseline wander noise and powerline interference from ECG. The proposed methods have been tested with simulated ECG signals and real ECG signals from the MIT-BIH arrhythmia database. The proposed methods are tested with four different PLI noise scenarios and with BW noise available at MIT-BIH noise-stress database at noise levels between -5 dB and 15 dB. The proposed methods are also evaluated using ECG signals available at MIT-BIH arrhythmia database with both PLI and BW noise. The experimental results of the proposed methods are compared with NSRLMS method, traditional filter based method (notch filter and Butterworth highpass filter), EMD method, EMD with wavelet method and EEMD method in terms of signal to noise ratio, root mean square error, cross correlation and computation time.

7.2 PROPOSED METHODS

Improved adaptive algorithm based on EMD (EMD-BLMS) method has been proposed for the removal of PLI and BW noise. The performance of the proposed method is better than all the existing methods
except NSRLMS for 50 Hz / 60 Hz PLI. For amplitude varying noise scenario, the convergence time of the proposed method is more than 10 seconds; hence the proposed method is unable to track the PLI. For removal of BW noise, at lower noise levels the performance of the proposed method is better than that of existing methods. At higher noise level, the convergence time of the proposed method is more than 10 seconds; hence it is unable to track the BW noise. For removal of both PLI and BW noise, the proposed method performs better than all existing methods. The computation time of the proposed method is reduced by 75% compared to EMD-LMS algorithm. The SNR of the proposed method is improved by 48.69% over NSRLMS, 38.61% over traditional filter and 2.53% over EMD-LMS method.

Improved adaptive filters based on EEMD algorithm (EEMD-LMS & EEMD-BLMS) have been proposed to remove PLI and BW noise. The performance of the proposed methods are better than the existing methods except NSRLMS for 50 Hz/60 Hz noise. For both amplitude and frequency varying noise, the proposed method performs better than NSRLMS method, traditional filter method and EMD with wavelet method but lower than EMD and EEMD method because the convergence time of the proposed method is more than 10 seconds. For BW removal, the performance of the proposed EEMD-LMS and EEMD-BLMS method are better than the existing methods. For removal of both PLI and BW, the performance of the proposed method is better than all existing methods. The computation time of the EEMD-BLMS method is reduced by 75% compared to EMD-LMS algorithm. The SNR of the proposed method (EEMD-BLMS) is improved by 27.12% over NSRLMS, 21.079% over traditional filter, 96.476% over EMD with wavelet method, 148.954% over EMD method and 50.824% over EMD method.
BEMD based method has been proposed to remove PLI and BW noise. The performance of the proposed method is comparable to EEMD method in amplitude varying PLI noise scenario at higher noise levels. At lower noise level, the proposed method is unable to detect the amplitude varying noise till the noise amplitude increases, hence the performance is lower than EEMD and EMD based method. For frequency varying and for fixed frequency PLI, the proposed method performs better than the existing methods. The performance of the proposed method is better than all the existing methods for BW noise and both PLI and BW noise scenario, at all noise levels. The computation time of the proposed method is reduced by 75% compared to EEMD method. In the proposed method, the reference signal acts as a rule for decomposition. The SNR of the proposed method is improved by 83.87% over NSRLMS, 71.409% over traditional filter, 5.950% over EMD and 5.447% over EEMD method. The number IMF components and the number of iterations needed for the decomposition of IMF component are decided by the reference signal. Hence, the performance of the proposed method depends on the reference signal.

Improved EEMD method has been proposed to remove PLI and BW noise. The proposed method performs better than all existing methods. For amplitude varying PLI noise scenario, the performance of the proposed method is comparable to the EEMD based method. For BW removal and for both PLI and BW removal, the performance of the proposed method is better than the existing methods. The computation time of the proposed method is reduced by 52% compared to EEMD method. The SNR of the proposed method is improved by 84% over NSRLMS, 71.526% over traditional filter, 11.35% over EMD and 5.52% over EEMD method.
Improved EEMD algorithm automatically detects the noisy ECG segment, processes only the noisy segment and removes the noise. Hence, the distortion in ECG is reduced. Thus, the proposed method can be used for automatic diagnosis and ECG monitoring which has the application in biotelemetry.

7.3 FUTURE WORK

The proposed method can be extended as follows: The proposed methods can also be extended to remove other artifacts which are present in ECG. The proposed methods can also be extended to improve the performance in amplitude and frequency varying PLI noise scenarios. The proposed methods can also be applied and tested to real time ECG monitoring and automatic arrhythmia diagnosis systems.