A New Method of Adaptive Filtering and Wavelet Transform to Filter Baseline Shift

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ABSTRACT

This article describes how a baseline shift is a slow change in the orientation of the baseline over time. It often exists in the process of signals sampling, e.g., ECG, TLC and so on. In order to filter the baseline shift, a combination method of wavelet transform and an adaptive filter is proposed. First, the wavelet transform method is used to decompose the original ECG signal and the high-frequency components are used to as Reference input data. Then, a new adaptive filtering algorithm, P-LMS, based on the power function, is proposed to conduct adaptive noise filtering. Finally, compared with the traditional normalized least mean square algorithm (NLMS), the proposed algorithm has the characteristics of faster convergence and the effect is better. Experiments on the ECG signal in MIT-BIH database, using the method of combining P-LMS and a wavelet transform is verified to effectively filter the baseline shift and maintain the geometric characteristics of the ECG signal.

KEYWORDS

Adaptive filter, Baseline shift, High-frequency, Noise, Normalized Least mean square algorithm, Power function, Signals sampling, Wavelet transform

INTRODUCTION

Baseline shift is a slow change in the orientation of the baseline over time. It often exists in the process of signals sampling, e.g., Electrocardiogram and Thin-Layer Chromatography (abbreviated TLC) and so on (Manuel et al., 2008; Sun et al., 2002). In TLC, When the flow and temperature settings change, baseline fluctuations or shift may occur. In the meanwhile, due to all kinds of interference and noises in the analysis of samplings inevitably, the baseline shift showing upper and lower that affect quantitative calculation, analysis and evaluation. The electrocardiogram (abbreviated ECG) is a technique that uses an electrocardiograph to record the patterns of electrical activity produced by each heart cycle in the heart. In other words, ECG is a reflection of the electrical activity of the heart. It has important reference value and also play an important role in the analysis and discrimination of various arrhythmias, myocardial infarction, myocardial ischemia and other disorders of diseases. The signal is extremely weak, vulnerable to the interference of external factors and influence, in the process of acquisition, transmission, recording and storage of ECG signal, the signal distortion is very easy to appear, deform and disappear. For more accurate and effective extraction of the ECG signal and provide reliable reference for medical diagnosis, it is better to reduce and restrain the noise signal, enhance the useful signal and improve the signal to noise ratio, which is also important in the ECG automatic analysis.

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Movement, respiration, skin impedance changes and hardware amplifier drift, etc. will lead to ECG baseline shift. Baseline shift is a low interference signal, which frequency is relatively low, in the range of 0.05 Hz -1.5Hz. In the actual measurement, the ECG signal will deviate from the normal baseline position, and there will be a slow fluctuation. As shown in Figure 1, there are two figures: figure (a) describes the normal ECG signal without the baseline shift and picture (b) describes the ECG signal with baseline shift; figure (b) describes the ECG signal with the baseline shift noise deviated from the normal position. Baseline shift is easy to cause the tracings of the graphic distortion, each band of ECG cannot be seen clearly, ST segment was raised or depressed artifacts and similar to a variety of serious arrhythmia phenomenon, which affect the medical diagnosis greatly (Huang, 2001; Liu, 2001). Therefore, how to correct the baseline shift is particularly important and it has become the key problem of restoring the original signal and making correct medical diagnosis.

There are two kinds of traditional baseline shift correction methods, one is blank correction and the other is manual method. The blank correction method is that a baseline was pre-drawn and then deducted from the sample curves; the manual method is that manually selects several points to pull together as a baseline, and then the fitting baseline is deducted. Both of the two methods are of great error and cannot reflect the changes of the baseline exactly. Therefore, many researchers try to study on other methods for baseline shift. Other methods such as Digital filtering, Baseline fitting, Adaptive filtering and Wavelet transform are used to correct baseline shift (Leski & Henzel, 2004; Francis, 2002; Esposito & D’andria, 2003; Reddy et al., 2009; Yang, 2014). Wavelet method has the advantages of multi-resolution analysis (Mallat, 1989), but the decomposition of the band selection cannot be automatically adjusted with the characteristics of the signal, and threshold selection is very important, the improper value, the influence of the degree of accuracy (Donoho, 1995). In addition, since the baseline is a slowly varying frequency signal, a method of curve fitting can be used for correction, but it is difficult to extract the difference point when the signal is weak. Park et al designed an adaptive wavelet filter, compared to its performance and adaptive filters, with greater advantages (Park et al., 1998).

In the study, the adaptive filtering method and wavelet transform are combined. With the selection of wavelet function and reference signal, a method of adaptive filtering based on wavelet transform

Figure 1. (a) The normal ECG signal without baseline shift; (b) the ECG signal with the baseline shift
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