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Signal Distortions In ECG Caused By Linear Digital Filtering

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Introduction

The enhancement of ECG by signal processing is a necessary task because of disturbances in real environment. Raw ECG is always interfered by artefacts like power line interference, baseline drift and overlapping EMG. Hence the extraction of important ECG parameters depends heavily on properly denoising methods.

Methods

Digital filtering is an effective tool for denoising. Several problems like the necessity of a linear phase response of digital filters to avoid shape distortions of signals are already addressed and solved e.g. by forward-backward filtering or linear-phase filter design by FIR. In our investigations another source of shape distortion in ECG after linear phase filtering has been detected. We suppose that this distortion is not known yet. Thus, this contribution describes and analyses the source of shape distortions.
ECG has been recorded by an amplifier which is capable to deliver raw, unfiltered signals. In first examinations of the signals, several low-pass FIR filters with a cut-off frequency of 40Hz were designed. We observed significant shape distortions in the time domain even after linear-phase filtering. The strength of the distortion depends mainly on the filter order: the higher the order, the heavier the distortions. We give recommendations to avoid these distortions.

Results

The R-Wave in an ECG can be seen as a narrow spike with high amplitude, which can be interpreted as an approximation of an Dirac impulse. Considering long impulse responses of high order FIR filters which are convolved by R-spike the distortions can be explained. They appear as fast waves which have neither physiological nor pathological origin.

Conclusion

Though there are several methods in enhancing ECG, digital filtering is an important one and widely used. But filter impulse responses caused by the R-Spikes can distort the ECG in time domain, as observed in our investigations. They will be examined further.