Is the Dominant Frequency Accurate Enough for Atrial Fibrillation Signals?

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Aim: In noninvasive studies of atrial fibrillation (AF), especially in body surface potential map (BSPM) measurements, the dominant frequency (DF) is usually defined as the highest peak in the power spectrum, after prior cancellation or removal of the ECG components related to the ventricular activity. However, the power spectrum is often hampered by the presence of residual artifacts caused by phase breaks in atrial signals due to either signal concatenation or to the chaotic behavior of AF. The aim of this study is to develop a novel estimator of DF, robust against phase breaks in atrial signals, and to compare it to FFT based approaches.

Methods: Four estimators were selected: traditional FFT computed on raw signals [FFT_raw], the median of the unwrapped angle from Singular Spectrum Analysis (SSA) [Median_ssa], the FFT from SSA [FFT_ssa], and a weighted average computed over each cosine period (AF cycle), determined by using the derivative of the signal phase [WA_cycle]. These estimators were compared on simulated data (Monte Carlo approach with 500 runs): one-minute long 6 Hz sinusoidal signals, with variable noise level, and with random stepwise time jumps to mimic phase breaks. The magnitude of these time jumps varied from 0 to ±(AF period) /2.

Results: For low amplitude phase breaks, all estimators gave similar results. However, for large phase breaks (±T/2 every half-second), and for a SNR of 5db, the 95 % confidence interval were: [5.37-6.62]Hz for FFT_raw, [5.84-6.15]Hz for Median_ssa, [5.59-6.40]Hz for FFT_ssa, and [5.86-6.13]Hz for WA_cycle.

Conclusions: Median_ssa and WA_cycle provided more accurate estimates with large phase breaks. These estimators were also applied to real data for illustration, with similar results. WA_cycle should be preferred when analyzing BSPM signals where a gradient of the dominant frequency is observed, whose analysis may be hampered by phase jumps in the atrial signal.