sEMG De-noising and Muscle Performance Evaluation

Miao Wu

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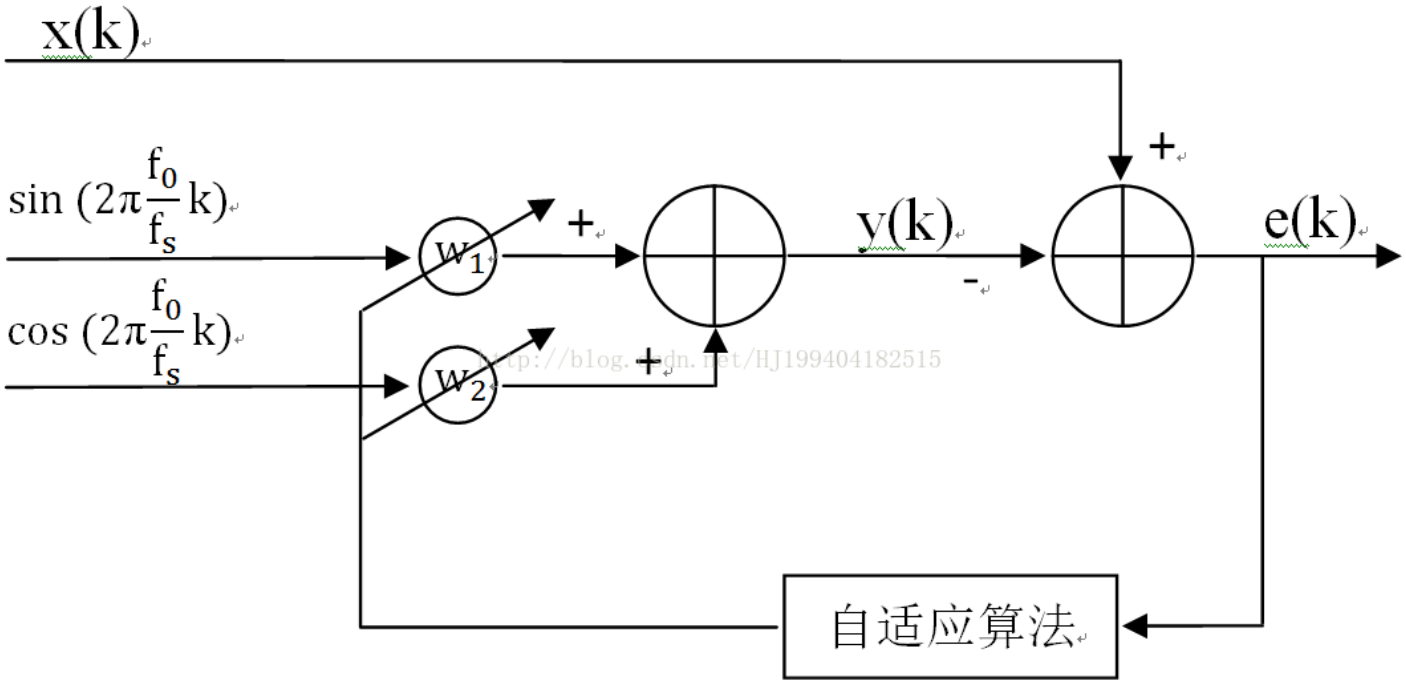
Adviser: Chenglong Fu

Adaptive filter

- Advantages
  - adjustable parameters
  - adaption to changing input signal environment and output signal characteristics
  - better performance in sEMG denoising

Theory



x(k): original signal with noises f0: frequency of noise
fs: sampling frequency w1 w2: coefficients
y(k): estimated noise e(k): error function
adaptive algorithm: Least Mean Square(LMS); Recursive Least Mean Square(RMS)

LMS vs. RLS

Filter	EMG1	EMG2	EMG3	EMG4
LMS algorithm	6.32	6.98	8.12	8.53
RLS algorithm	8.77	7.41	9.27	9.14
Wavelet db4	7.66	7.35	8.45	8.13
0.34-1 HZ bandpass filter	5.44	4.63	4.88	5.75

SNR values (in db) of denoised uterine EMG signals

RLS algorithm

RLS 算法：

$$x(k)=\begin{bmatrix}\sin(2\pi\frac{f_0}{f_s}k)\\ \cos(2\pi\frac{f_0}{f_s}k)\end{bmatrix}$$

f_0 为噪声信号频率，f_s 为采样频率，$x(k)$ 为信号矢量

$$K(k)=\frac{P(k)x(k)}{\lambda+x^T(k)P(k)x(k)}$$

$K(k)$ 为增益矢量维度为 2×1；λ 为遗忘因子，一般取值为 0.95-0.9995；$P(0)=\delta^{-1}I$，其中 δ 为一个小正数（程序中取为 0.01）保证矩阵 P 非奇异，I 为 2×2 单位矩阵，故 P 为 2×2 对角矩阵

$f(k)$ 为滤波器系数矢量维度为 2×1，$f(0)=\begin{bmatrix}0\\0\end{bmatrix}$

$$y(k)=x^T(k)f(k)$$

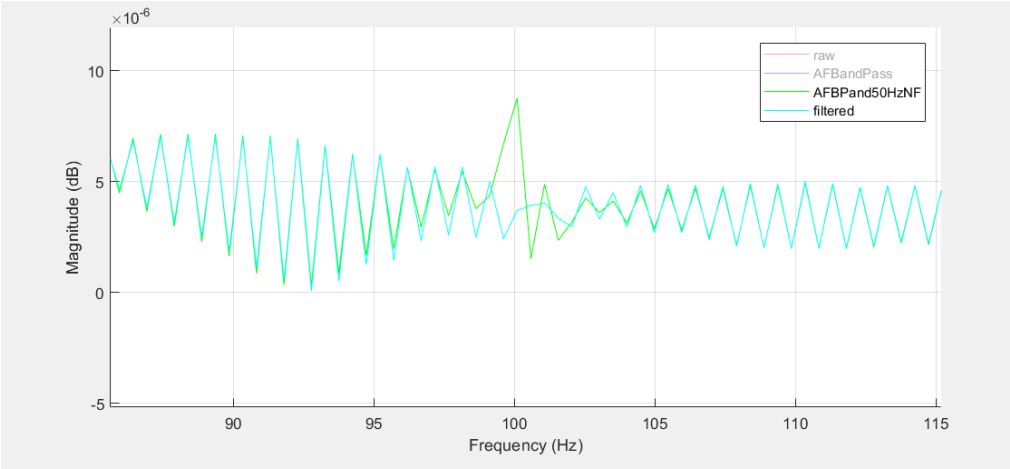
$$e(k)=d(k)-y(k)$$

$d(k)$ 为原始信号，$y(k)$ 为计算出来需要滤除的信号，$e(k)$ 为滤波后的信号

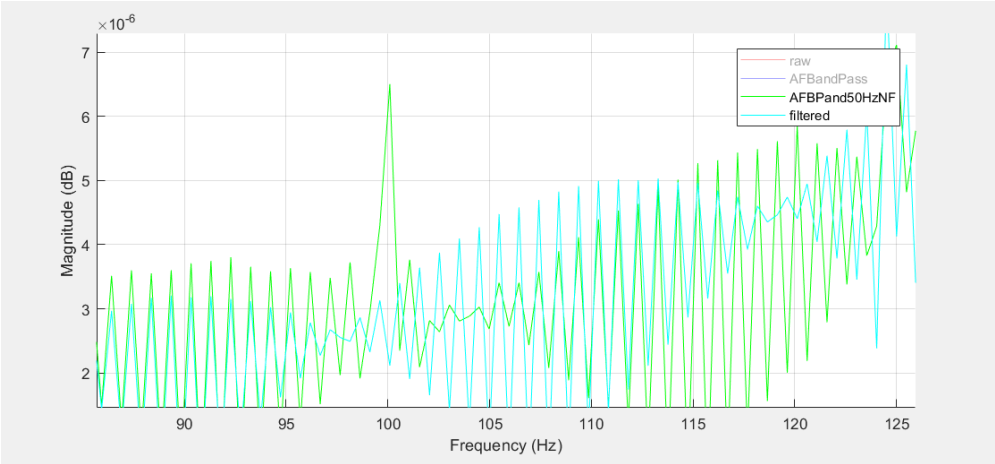
$$f(k+1)=f(k)+K(k)e(k)$$

$$P(k+1)=\lambda^{-1}P(k)-\lambda^{-1}K(k)x^T(k)P(k)$$

Conclusion



100Hz notch filter with fixed parameters



100Hz adaptive notch filter

Literature Review

- Muscle force estimation
  - Neural Muscle Force Estimator(NMFE)
  - Fuzzy Muscle Force Estimator(FMFE)
- Procedure
  - first layer: neural network
  - second layer: neural network theory; fuzzy logic algorithms

乌萨马.根据肌电图(EMG)信号评估人手臂肌肉力和肌肉疲劳的人工智方法[D].武汉:华中科技大学博士学位论文.2013.

Thanks