Additive Step Artifact Correction (ASAC) Algorithm

X. Sui, L. Yin, I. W. Selesnick, H. L. Graber, R. Al abdi and R. L. Barbour

This abstract address the problem of removing step artifacts from a predominantly low-pass signal. In particular, we consider the case where the step artifacts have an appreciable rise time rather than exhibiting instantaneous step discontinuities. The problem arises in certain physiological measurements, such as near infrared spectroscopic (NIRS) time-series imaging. NIRS is an attractive non-invasive cortical imaging technique [1]. However, this kind of step artifact, caused by detection approach, is one of the difficulties in breast NIRS data analysis.

The suppression of ideal step artifact has been addressed in previous work, such as total variation denoising (TVD) and simultaneous low-pass filtering and total variation denoising (LPF/TVD) [2] [4]. However, they are not appropriate in this practice. In this abstract, we consider the more practical step artifact which has exponential leading and trailing edges and propose a sparsity-based signal model to represent it. It is assumed that the raw data $\mathbf{y}$ can be modeled as a noisy additive mixture of a low-pass signal $\mathbf{f}$ and this particular step artifact $\mathbf{x}$. Based on this model, an optimization problem which involves a sparse-inducing penalties is proposed. A convex optimization approach is presented and the resulting additive step artifact correction (ASAC) algorithm derived based on majorization-minimization (MM) [3]. The computational efficiency stems from the use of fast solvers for banded systems of linear equations.

The algorithm is demonstrated on simulated model data and the experimental NIR time-series data respectively. The mean squared error (MSE) of the corrected data is smaller than those by other methods, as shown in Table I. Also, it is shown in Figure 1 that the method works well on true NIRS step artifact correction. Twenty iterations takes about 15 milliseconds on a 2012 MacBook Air (2 GHz Intel Core i7) running Matlab R2014a. Therefore, ASAC method can be developed to a potential technique for NIRS additive step artifact correction.

X. Sui, L. Yin, I. W. Selesnick are with the Department of Electrical and Computer Engineering, NYU Polytechnic School of Engineering, 6 Metrotech Center, Brooklyn, NY 11201.

H. L. Graber, and R. L. Barbour are with the Department of Pathology, SUNY Downstate Medical Center, Brooklyn, NY 11203.

R. Al abdi is with the Biomedical Engineering Department, Jordan University of Science and Technology, Irbid 22110, Jordan

TABLE I: Comparison of quantitative experimental results for different methods on simulated model data

	ASAC	LPF/TVD	TVD
MSE	0.027	0.124	3.354

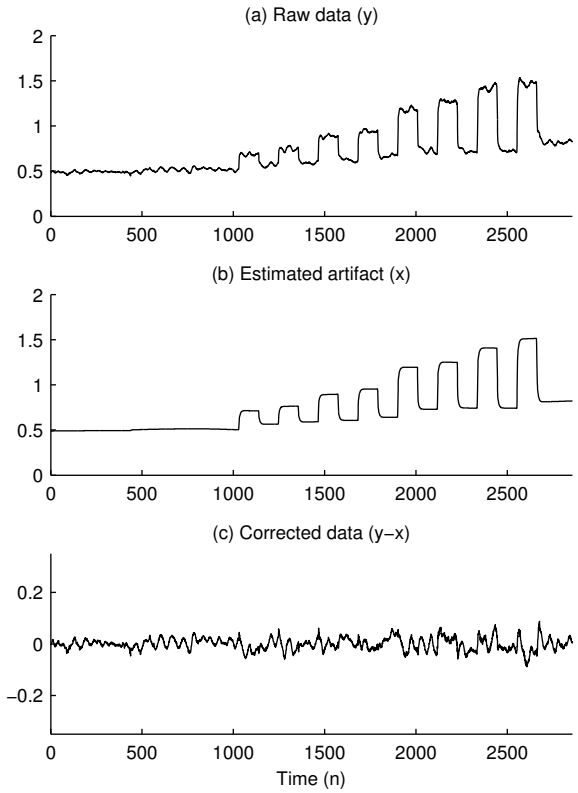

Fig. 1: Step artifact correction using ASAC with arctangent penalty function. (a) NIRS data. $\mathbf{y}$. (b) Estimated step artifact, $\mathbf{x}$. (c) Corrected data, $\mathbf{y} - \mathbf{x}$.

REFERENCE

[1] R. Al. abdi, H. L. Graber, Y. Xu, and R. L. Barbour. Optomechanical imaging system for breast cancer detection. *J. Opt. Soc. Am. A*, 28(12):2473–2493, Dec 2011.

[2] S. Osher L. Rudin and E. Fatemi. Nonlinear total variation based noise removal algorithms. page 60:259268, 1992.

[3] I. Selesnick. Sparse deconvolution (an MM algorithm). *Connexions*, 2012. http://cnx.org/content/m44991/.

[4] I. W. Selesnick, H. L. Graber, D. S. Pfeil, and R. L. Barbour. Simultaneous low-pass filtering and total variation denoising. *IEEE Trans. Signal Process.*, 62(5):1109–1124, March 2014.