Robust Variable Step-size Sign Subband Adaptive Filter Algorithm Against Impulsive Noise

Pengwei Wen , Jiashu Zhang

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***Abstract*—The main drawback of the sign subband adaptive filter algorithm (SSAF) is its large steady-state error and poor tracking capability. A robust variable step-size SSAF algorithm is presented to improve the performance, which uses the optimal step-size for each subband by minimizing the mean square deviation. Since the step-size contains the variance of noise-free *priori error*, the shrinkage denoising method is used to estimate the noise-free error signal. With the step-size adaptation influenced by the variance of error signal for each subband, the proposed algorithm is shown to achieve a significant improvement in both the convergence rate and the steady-state error than the SSAF algorithms. Besides, the proposed algorithm offers robust performance with respect to impulsive noise and good ability of tracking unknown system. Finally, simulation results demonstrate that these features of the proposed algorithm in system identification and echo-cancellation applications.**

***Index Terms*—subband adaptive filtering, shrinkage, robust, impulsive noise.**

1. Introduction

Because of the inherent decorrelating property of the normalized subband adaptive filtering (NSAF) algorithm [1-2], the NSAF algorithm converges faster than the least mean square (LMS) and the normalized least mean square (NLMS) algorithm for the colored input signals. However, when background noise includes impulsive noise, the performance of the NSAF algorithm will degrade. To improve the robustness of filter performance against impulsive noise, the sign subband filter algorithm (SSAF) was derived by minimizing the l_1-norm of the subband a posteriori error vector of the filter in [3]. A novel sign subband adaptive filter with individual weighting factor (IWF-SSAF) was proposed to improve the performance of SSAF in [4]. Because of using a constant step-size, the performance of SSAF and IWF-SSAF has an intrinsic trade-off between steady-state misalignment and convergence speed.

The dilemma could be solved by means of using variable step-size, and several algorithms have been presented in [3, 5-7]. Ni et al. proposed a variable regularization parameter SSAF (VRP-SSAF) algorithm to improve the performance [3]. However, this algorithm has a poor capability of tracking non-stationary systems and is seriously depend on its parameters. The VSS-SSAF was derived by minimizing the mean square deviation (MSD) in [5]. Although the algorithm obtains a low steady-state error, it has a low convergence rate and a poor tracking capability. J.H.Kim proposed another VSS-SSAF by minimizing the l_1-norm of the subband *posteriori* error under a box-constraint on the step-size [6]. Since the step-size of the algorithm adaptive updates its boundaries, the VSS-SSAF could achieve fast convergence speed and small steady-state estimation error under stationary systems, its re-adaptation ability degrades in changed environment. Recently, the BDVSS-SSAF algorithm was proposed by using the concept of MSD in [7]. Its step-size is derived by minimizing the upper bound of the conditional MSD with the inputs. By using the reset algorithm, the algorithm could maintain the filter performance when system change occurs suddenly. However, it still has a low convergence rate.

This paper proposes a robust variable step-size SSAF algorithm, which is derived by minimizing the MSD between the optimal weight vector and the weight vector estimate. We use the shrinkage method to obtain the accurate estimation of noise-free subband *posteriori error*. Due to the power of estimation error related to the step-size adaptation for each subband individually, the proposed algorithm is capable of tracking unknown system. Finally, compared with other cited algorithms, the simulation results show that the proposed algorithm offers a faster convergence speed, lower steady-state estimation error and better tracking capability in the presence of impulsive noise.

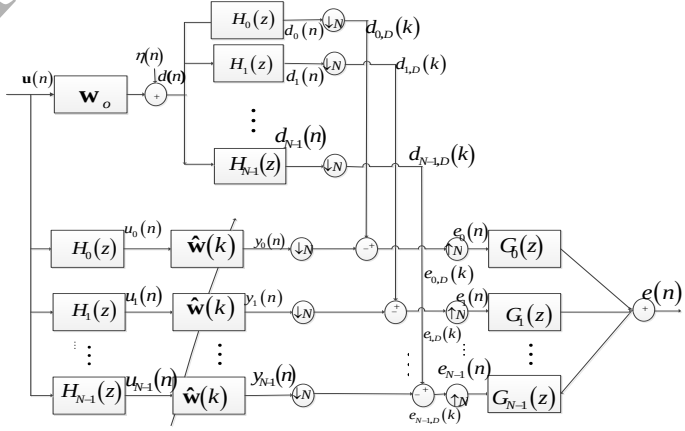

Fig. 1 structure of SSAF

2. Review of conventional SSAF algorithm

Fig. 1 shows the structure of the subband adaptive filter [8].Consider a desired signal

$$d(n)=\mathbf{u}^T(n)\mathbf{w}_o+\upsilon(n) \tag{1}$$

where $\mathbf{u}(n)=[u(n), u(n-1),\cdots, u(i-M+1)]^T$ is an m-dimensional input vector, $\mathbf{w}_o$ and $\upsilon(n)$ denote the unknown weight vector with the length M and the background noise, respectively. The background noise $\upsilon(n)$ includes the white Gaussian background noise $\eta(n)$ and impulsive noise $\varsigma(n)$,The noise $\upsilon(n)$ and $\mathbf{u}(n)$ are independent in statistics, and given to be stationary and zero mean. In Fig.1, the signals $\mathbf{u}(n)$ and $d(n)$ are decomposed into $\mathbf{u}_i(n)$and $d_i(n)$ by the analysis filters $H_i(z)(i=0, 1\ldots N-1)$. The subband desired output signals $y_i(n)$

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P.Wen and J.Zhang are with the Sichuan province Key Lab of Signal and Information Processing at Southwest Jiaotong University, Chengdu, 610031,P.R.China.(E-mail:623101594@qq.com,jszhang@home.swjtu.edu.cn).