Journal of Information and Computing Science
J. Info. Comput. Sci., Vol. 19, No. 1, pp. 53-64

DOI: 10.4208/JICS-2024-004
June 2024

# Frequency Domain Acoustic Echo Cancellation Using Auxiliary Function Based Independent Component Analysis

Lifu Wu[1,2,*], Lei Wang[1], Xinnian Sun[1] and Shuaiheng Sun[1]

[1] *School of Electronics and Information Engineering, Nanjing University of Information Science and Technology, Nanjing 210044, China*

[2] *Collaborative Innovation Center of Atmospheric Environment and Equipment Technology, Nanjing University of Information Science and Technology, Nanjing 210044, China*

**Abstract.** The performance of traditional Acoustic Echo Cancellation (AEC) is restricted due to the double-talk detector it used to determine the double-talk and single-talk scenarios. While Blind Source Separation (BSS) signal model is a full duplex model with both far-end and near-end signals, thus the BSS-based AEC does not need the double-talk detector. This paper adopts Auxiliary function based Independent Component Analysis (Aux-ICA) algorithm to realize acoustic echo cancellation in frequency domain, in which the object function is minimizing the mutual information, and the auxiliary function technique is used for optimization. Simulation results show that this method has lower computational complexity and better performance in acoustic echo cancellation under continuous double-talk scenarios.

**AMS subject classifications:** 62H25, 68W40

**Key words:** Echo cancellation, Auxiliary function, Independent Component Analysis (ICA), Blind source separation, Double-talk

## 1 Introduction

In network conference, hands-free call and other applications, there are different degrees of acoustic echo problems. The existence of echo affects the quality of communication, and the communication system cannot work normally if it is serious. Therefore, effective

Translated from *Journal of Nanjing University of Information Science & Technology*, 2023, 15(3): 323-329.
*Corresponding author. *Email addresses:* **wulifu@nuist.edu.cn** (L. Wu).

measures must be taken to suppress the echo and eliminate its influence. Echo cancellation is a method usually used. Its basic idea is to estimate the echo path, get the estimate of the echo signal, subtract the estimated signal from the microphone signal, and realize the echo cancellation.

Adaptive filtering [1] is one of the common methods of acoustic echo cancellation. Normalized Least Mean Square (NLMS) algorithm [2-3] is a typical algorithm for echo cancellation, which minimizes the mean square error between the estimated echo and the microphone signal through gradient descent. To prevent filter divergence, additional use of a Double-Talk Detector (DTD) [4] or an adaptive step strategy [5] is required to slow or stop adaptive filter adjustment during double-ended talk. Recursive Least Square (RLS) [6] is also an AEC algorithm, and compared to the NLMS algorithm, the RLS algorithm has a faster convergence rate, but its computational complexity is also higher. Speex MDF [7] is a widely used adaptive filter echo cancellation algorithm. Based on NLMS algorithm, it is implemented by Multi Delay block Frequency domain (MDF) filtering algorithm, and the optimal step size estimation is derived. The advantage is that the filter coefficient is based on block update.

The AEC method mentioned above has some shortcomings. The method based on gradient descent has a balance problem between convergence speed and stability [8]. Although DTD and adaptive step strategies work well in both one-way and occasionally two-ended call scenarios, their performance can degrade in continuous two-ended call scenarios where the near-end signal is always present [9]. Blind source separation [10-11] is a technique that separates the desired signal from the observed mixed signal to achieve signal separation or enhancement. Independent Component Analysis (ICA) [12] and Independent Vector Analysis (IVA) [13] are typical BSS techniques. AEC can be thought of as a semi-blind source separation problem, where the goal is to separate the echo from the near-end signal from the microphone (microphone) signal.

In recent years, although the echo cancellation method based on Deep Learning [14-15] has shown good performance, this data-driven method has two main shortcomings: First, it needs enough data for training. Although there are some open-source audio databases, these databases are usually not enough to build robust neural networks; The second is that the parameters of the deep neural network cannot be interpreted, which is unacceptable to engineers or actual users who want to manipulate and adjust the performance of the echo cancellation system to their own needs.

Compared with the traditional AEC algorithm, because the BSS signal model is a full-duplex model with both remote and near-end signals, the BSS based AEC algorithm has better echo cancellation capability in the continuous two-end call scenario. At the same time, the excellent performance of Speex MDF algorithm shows that the implementation of AEC in frequency domain has certain advantages. Therefore, this paper adopts independent component analysis based on auxiliary function to realize acoustic echo cancellation in frequency domain. Based on full-duplex characteristics, auxiliary function technology is used to avoid explicit step parameter selection and reduce the computational complexity of the algorithm.