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Performance Analysis of Modified Affine Projection Algorithm and It's Application

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Abstract

We are developed a modified version of affine projection algorithm for acoustic echo cancellation, which has moderate convergence speed and noise-robust characteristics. The proposed algorithm normalizes the update equation to reduce noise effect of affine projection algorithm, by adding the multiplication of estimation error power and projection order to auto-covariance matrix of input signal. The proposed algorithm has noise robust characteristics and good steady-state performance. We also present an analysis of the convergence behavior of proposed algorithm using a simple model for the input signal vector with the usual independence assumption.

1. Introduction

Adaptive signal processing is concerned with the design, analysis and implementation of systems whose structure changes in response to the incoming data[1]. Nowadays, adaptive filtering techniques are used in a wide range of applications, including system identification, echo cancellation, adaptive equalization, adaptive noise cancellation, and adaptive beamforming. These applications involve processing of signals that are generated by unknown systems. Under this condition, a significant improvement in performance can be achieved by using adaptive rather than fixed filters.

The NLMS algorithm is widely used in many applications where the input signals are subject to widely fluctuating power levels. It is normalized LMS algorithm[4] that normalizes the adaptation constant with respect to input signal power. However, it has a drawback of converging slowly, especially when the input is colored. RLS algorithm exhibits fast convergence in colored or correlated inputs, but it has heavy computational burdens[2]. Another widely used algorithm is the affine projection (AP) algorithm[5]. The AP algorithm is a generalization of the NLMS adaptive filtering algorithm. Namely, NLMS algorithm is one-dimensional affine projection algorithm. Lying somewhere between the LMS algorithms and RLS algorithms are a class of algorithms which allow the system designer to choose complexity and performance by changing parameters without changing algorithms. The system designer may effectively trade increased computational complexity for improved convergence rate performance[3]. In many cases, it is possible to achieve an improved convergence rate with only a marginal increase in computation. Nevertheless, when a projection is performed, noise amplification problem always arises and this phenomenon degrades the performances of the AP algorithm.

But above mentioned three algorithms have noise-weak characteristic in noisy environment. So a noise-robust adaptive algorithm is required. In 1998, Greenberg proposed a noise-robust sum LMS algorithm[6]. But the convergence speed is too slow to apply in real application because of its LMS basis. Hence, an adaptive algorithm, which has noise-robust characteristic and fast convergence speed, is necessary. And in 1999, J.S Park proposed noise robust NLMS algorithm[7], which is faster than sum LMS algorithm in convergence speed. But the convergence speed of this algorithm cannot excel that of NLMS.

Our work is aimed at developing the modified AP algorithm, which has moderate convergence speed and noise-robust characteristic. In this paper, a new modified AP algorithm is proposed to reduce noise amplification problem of AP algorithm. The proposed algorithm normalizes the update equation to reduce noise amplification of AP algorithm, by adding the multiplication of error power and projection order to auto-covariance matrix of input signal.

2. Modified Affine Projection Algorithm

A new modified AP algorithm is proposed to reduce noise amplification problem of AP algorithm[8]. The proposed modified AP algorithm normalizes the update equation to reduce noise amplification of AP algorithm, by adding the multiplication of error power and projection order to auto-covariance matrix of input signal. The general form of proposed algorithm is as (1) and (2).

$$\mathbf{e}_n = \mathbf{d}_n - \mathbf{X}_n^t \mathbf{w}_n \qquad (1)$$

$$\mathbf{w}_{n+1} = \mathbf{w}_n + \mu \mathbf{X}_n \left[\mathbf{X}_n^t \mathbf{X}_n + P \cdot L \cdot \sigma_{e,n}^2 \mathbf{I} \right]^{-1} \mathbf{e}_n \qquad (2)$$

$$\sigma_{e,n}^2 = \beta \sigma_{e,n-1}^2 + (1-\beta) e_n^2$$