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Diffusion normalized Huber adaptive filtering algorithm

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Abstract

In this paper, we propose an adapt-then-combine (ATC) diffusion normalized Huber adaptive filtering (ATC-DNHuber) algorithm for distributed estimation in impulsive interference environments. Firstly, a normalized Huber adaptive filter (NHuber) is developed to reduce the effect of the eigenvalue spread of the input signal. Then we extend the NHuber to develop an ATC diffusion algorithm by applying the NHuber algorithm at all agents. In addition, the mean stability performance and computational complexity are analyzed theoretically. In addition, Furthermore, simulation results demonstrate that the ATC-DNHuber algorithm can perform better in identifying the unknown coefficients under the complex and changeable impulsive interference environments.

1. Introduction

Adaptive filter algorithms are frequently employed in equalization, active noise control, acoustic echo cancellation, biomedical engineering and many other fields [1,2]. Adaptive networks are an extension of adaptive filters over graphs. Three cooperation strategies for distributed estimation over networks are widely used, i.e., the incremental, consensus, and diffusion strategies [3]. The incremental solution suffers from a number of drawbacks for real-time adaptation and learning over networks. The consensus technique suffers from the

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asymmetry problem which can cause an unstable growth in the state of the network. It is noteworthy that the diffusion strategies can remove this asymmetry problem. The diffusion strategies include adapt-then-combine (ATC) scheme [4] and combine-then-adapt (CTA) scheme [5]. For ATC scheme, first step is updating the local estimate by using adaptive filtering algorithm, then the intermediate estimates for the neighbors are fusing together. For CTA scheme, data fusion is performed first, then updates the local estimate by using the adaptive algorithm. These two kinds of structure are very valuable, Cattivelli and Sayed analyzed the performance of these two structures. The analysis results show that the ATC scheme outperforms the CTA scheme [4]. So, the ATC scheme become a research focus. Then, a variety of distributed estimation algorithms were proposed, such as diffusion LMS (ATC-DLMS) algorithm [4], z^2-proportionate diffusion LMS algorithm [6], diffusion normalized LMS algorithm (ATC-DNLMS) [7], and distributed recursive least-squares (DRLS) algorithm [8].

In recent years, distributed estimation has been widely used in many applications [4]. Distributed estimation has received more and more attention recently [9]. It is known that the measurement noise is always the research focus. Significantly, most of the distributed estimation algorithms suffer from impulsive interference. Recently, the diffusion least-mean p-power (ATC-DLMP) algorithm with fixed power p for the distributed parameter estimation in α-stable noise environments has been proposed in [10]. For a given signal model, the performance of the LMP type methods is affected by p. In addition, to improve the robustness of distributed estimation against impulsive interference, a diffusion sign subband adaptive filtering (DSSAF) algorithm was presented in [10]. However, if the unknown vector has a small number of entries, the computational complexity of the DSSAF algorithm may be higher. Besides, Ni et al. [11] presented a diffusion sign-error LMS (ATC-DSE-LMS) algorithm, which is obtained by modifying the ATC-DLMS algorithm [4] by applying the sign operation to the error signals. Then the stochastic behavior of the ATC-DSE-LMS algorithm is analyzed for Gaussian input signals based on Price's theorem. The ATC-DSE-LMS algorithm is simple and can be implemented easily, and it does not introduce any signal delay. But a lower stable-state error is the main defect of the ATC-DSE-LMS algorithm. It is worth noticing that in order to design an adaptive filter suitable for both the Gaussian noise and impulsive interference environments, a Huber adaptive filter is proposed, which is a hybrid of the l_2 and l_1 norms [12,13]. But the stability of Huber adaptive filtering algorithm is very easy to be affected by the eigenvalue spread of the autocorrelation matrix of the input signal.

From the results of the above analysis we can know that those shortcomings of the above mentioned diffusion algorithms in the presence of impulsive interference need to be solved urgently. So, an ATC diffusion normalized Huber adaptive filtering (ATC-DNHuber) algorithm is proposed in this paper. Firstly, a normalized Huber adaptive filter (NHuber) is developed. Then we extend the NHuber to develop this ATC-DNHuber algorithm by a network of agents. The mean stability performance and computational complexity are analyzed theoretically. Finally, we have carried out three system identification simulation experiments to illustrate significant superiorities of the ATC-DNHuber algorithm. Through theoretical analysis, we know the ATC-DNHuber algorithm can be approximated as a mixture of an ATC-DNLMS algorithm and a normalized ATC-DSE-LMS algorithm and dynamic switching according to different situations. Simulation results demonstrate that the ATC-DNHuber algorithm is robust against impulsive interference.

The remainder of this paper is organized as follows. The proposed ATC-DNHuber algorithm is discussed in detail in Section 2. The statistical behavior of the ATC-DNHuber algorithm, including the stability performance, computation complexity and b for the