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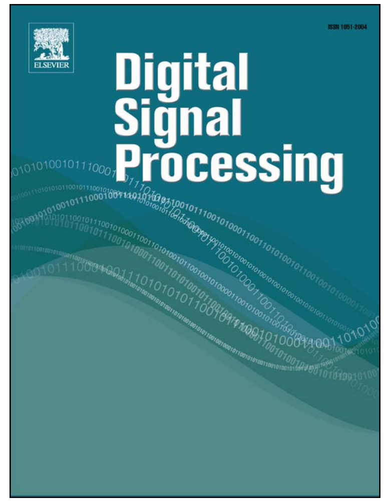

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Distributed Sparse Diffusion Estimation based on Set Membership and Affine Projection Algorithm

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Abstract

The wireless sensor networks (WSNs) is the result of evolution of wireless and networking technologies, micro-electromechanical systems, and micro-services. One important task which can be performed by nodes in WSNs is to find a common solution to a problem by using distributed processing. In this paper, we study the problem of distributed estimation, where a group of nodes are required to collectively estimate a sparse parameter vector of interest, and we solve it by an estimation algorithm based on the set membership (SM) and affine projection (AP) methods. At each iteration of the algorithm, in addition to the current data, the proposed algorithm uses data obtained from previous measurements to attain faster convergence rate. A method is also proposed to select the constraint bound for set membership such that the computational load is uniformly distributed among the nodes of network. Then the distributed estimation algorithm is analyzed and a closed form expression for the steady state mean square deviation (MSD) is developed. The performance of proposed method is assessed via computer simulations. The simulation results show that the proposed algorithm provides faster convergence rate and smaller steady state MSD value when compared to conventional methods such as diffusion least mean squares (LMS), distributed set membership normalized LMS (DSM-NLMS), and distributed APA. Moreover, it achieves lower computational load compared to the AP method. These advantages make the proposed method useful in sparse parameter vector estimation whenever the nodes have sufficient memory size.

Keywords: Sparse adaptive filters, set membership, affine projection, diffusion network, distributed estimation, energy conservation relation.

1. The Introduction

In the wireless sensor network (WSN), a lot of nodes such as sensors and actuators are interconnected to acquire, share, and process data in order to achieve a common decision about an intended problem [1, 2]. The WSN can be deployed in various areas with low cost. A lot of different applications in smart grids, target detection, tracking, etc., are considered in WSNs due to their capabilities for real time and collaborative data processing [3, 4]. In general, designing a WSN poses important challenges such as energy consumption, flexibility with large number of sensors, link losses, topology changes, and cooperative signal processing. There are a number of robust algorithms to cope with these challenges. Some of the most recent and significant algorithms use distributed processing or consider some important feature of the problem such as sparsity.

Using adaptive distributed networks, in which each node coordinates with its neighboring nodes to process data, is a potential solution for the challenges mentioned above [5, 6]. Two well-known strategies for real time distributed processing over networks are consensus [7, 8] and diffusion [9, 10]. Diffusion strategies allow information to diffuse more easily in the network and result in faster convergence and lower mean square deviation (MSD) as compared to consensus one [11]. A discussion about the diffusion strategies is included in [12], where the problem addressed is the estimation of a parameter vector ω^o by using a collection of n sensors. The vector of interest is the minimum of a global cost function depending on ω^o. Every node has only partial information about the global cost function, and the measurements at each node are quantized to some discrete levels. Hence, the cooperation among nodes can be useful in obtaining more precise estimation of the parameter vector ω^o and for improving both learning and tracking capabilities [9] even when the transmission links are noisy [13]. In addition, recent advances in distributed estimation field propose one bit distributed estimation algorithm when the data is the sign of measurements, i.e., the measurements are quantized to two levels [14]. However, the measurements are assumed to be continuous in this paper.

When the parameter vector ω^o is sparse, i.e., it contains a few large coefficients and the rest are small enough to be neglected [15, 16], we can make use of the sparsity

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