A CLASS OF COOPERATIVE ADAPTIVE ESTIMATION ALGORITHMS BASED ON AFFINE PROJECTION

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Abstract

Standalone adaptive filters are subject to different tradeoffs. Selection of the design parameters introduces a tradeoff involving speed of convergence, steady-state misadjustment and tracking capability. To overcome this, many design procedures have been developed. These algorithms, however, require some *a priori* knowledge of the filtering scenario. In an alternative, adaptive estimation schemes are developed which, through cooperative learning reduce sensitivity of the filter to the choice of design parameters. The idea is to combine the outputs of two or more adaptive filters (running independently or in networked fashion) in an efficient way to achieve better performance than that of a single adaptive filter.

In this dissertation, we first consider the problem of identifying sparse systems whose sparsity varies over time and also, which are driven by correlated input. For this, using the convex combination framework, we adaptively combine the output of two independently-run adaptive filters, one sparsity unaware affine projection algorithm (APA) and the other sparsity aware zero attracting affine projection algorithm (ZA-APA). A detailed performance analysis of the proposed combination reveals that while for highly sparse and highly non-sparse systems, the proposed combination converges respectively to the ZA-APA and the APA (i.e., better of the two filters under the given levels of sparsity), for certain sparsity ranges, it leads to an overall filter that performs better than both the constituent filters.

Next we consider the problem of adaptive estimation over distributed networks in which dispersed agents are involved in estimating multiple parameter vectors (different but related) in a collaborative fashion. We propose an APA based clustered multitask diffusion strategy that effectively estimates multiple parameter vectors over a distributed sensor network under temporally-correlated input conditions. Though the proposed scheme is more effective than the non-cooperative schemes, its performance, however, suffers from its inability to adjust the degree of cooperation between nodes belonging to neighboring clusters, especially near convergence when the cooperation should be terminated as the nodes estimate different parameter vectors, and also when one of the collaborating nodes performs much worse than the other. To address this, we propose an adaptive regularizer scheme that regulates the degree of cooperation among the neighboring clusters in an intelligent manner. This improved strategy exhibits both faster convergence rate and lesser steady-state mean square deviation (MSD) than achieved by the state-of-the-art. Performance of the proposed strategies is studied analytically and through detailed simulations.

Finally, we propose an energy-efficient APA based clustered multitask diffusion strategy in which each node shares only a part of its intermediate estimate vector with its neighbors. The proposed algorithm, namely, clustered multitask *partial* diffusion APA reduces the required communication load as much as possible to save transmission energy while maintaining the benefits of cooperation. An analysis and numerical simulations reveal that even though the estimation performance deteriorates somewhat as the number of coefficients transmitted to the neighboring nodes decreases, the degradation can be compensated to a large extent by a proportional increase in the magnitude of the regularization strength among the neighboring clusters.

Keywords: Adaptive filters, afffine projection algorithm (APA), cooperative learning, adaptive convex combination, distributed adaptive estimation, adaptive diffusion networks, Multitask learning, partial diffusion, sparsity aware norm-constrained adaptive filters, excess mean square error (EMSE), mean square deviation (MSD).