ABSTRACT

Sparse system identification is one of the newly emerged areas of adaptive signal processing. The sparsity promoting norm regularized adaptive filters arguably form one of the most popular families of sparse adaptive filters for both standalone and distributed scenarios. However, they suffer from some major shortcomings of parameter selection issues for systems with variable sparsity and coefficients with arbitrary magnitudes. Also, increasing computational burden due to the additional sparsity promoting terms is another major concern for sparse adaptive networks.

In this dissertation, we first propose an adaptive convex combination based approach for identifying variably sparse systems using a novel combination of the zero attracting normalized least mean square (ZANLMS) and the NLMS based adaptive filters. It is shown that while for highly sparse and highly non-sparse systems, the proposed combination switches to the ZANLMS and the NLMS based adaptive filters respectively (better of the two under given levels of sparsity), for certain sparsity ranges, it results in an overall filter even better than either of the constituent filters. We further propose a *block-based* convex combination, where both the filter impulse responses are partitioned in non-overlapping blocks and adaptive convex combination is carried out on the output of the respective blocks from the two filters. The block-based approach outperforms the first one at the cost of increased computational requirement.

Next, we propose a computationally inexpensive *'heterogeneous'* sparse diffusion LMS which incorporates two different types of nodes: ZA-LMS based and LMS based. The proposed network is as effective as its 'homogeneous' counterparts, and we show it by proving that the minimum level of the steady state network mean square deviation achieved using ZALMS based update *at all the nodes* of the network can also be obtained by the 'heterogeneous' network with only a fraction of the nodes using ZALMS update rule while the rest employing the standard LMS update. We next develop a new sparse diffusion recursive least squares (RLS) algorithm which shows faster convergence simultaneously with lesser steady state network MSD than the existing algorithms. A heterogeneous counterpart of the above sparse diffusion RLS is then proposed.

Lastly, we consider a recently proposed l_0-RLS algorithm, for which we carry out a convergence analysis. Based on the results of this analysis, we propose a combination scheme to improve the performance of the l_0-RLS algorithm in a scenario where signal-to-noise ratio varies over time. Finally, we propose a new l_0-RLS algorithm by approximating the l_0 norm of a vector in terms of a weighted l_2 norm. The proposed algorithm shows far superior convergence behavior vis-a-vis existing algorithms.

Keywords: Sparse systems, adaptive filter, least mean square (LMS), normalized LMS, recursive least squares (RLS), adaptive convex combination, adaptive diffusion network, l_0 'norm', l_1 norm, l_2 norm, zero attracting(ZA) NLMS, reweighted ZANLMS, l_0 NLMS, l_0 RLS, mean square deviation (MSD), excess mean square error (EMSE), network MSD (NMSD), steady state MSD.