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Distributed adaptive signal estimation in wireless sensor networks with noise in the exchanged signals

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Abstract

Signal estimation in a wireless sensor network (WSN) aims to recover a desired signal from the noisy observations of a set of sensors deployed over a certain area. Distributed processing provides a division of the signal estimation task across the nodes in the network, such that said nodes need to exchange pre-processed data instead of their raw sensor observations. This is advantageous because it reduces the volume of data that needs to be exchanged, and wireless communications generally cost the node more energy than the local computations required to generate these pre-processed data [1].

The distributed adaptive node-specific signal estimation (DANSE) algorithm [2] relies on the exchange of optimally fused signals to achieve the performance of its centralized equivalent. However, additional noise can be present in these fused signals, such as noise introduced intentionally by quantization, targeting data reduction, or unintentionally by communication errors. In this case, the theoretical justification of the fusion rules in the traditional DANSE algorithm is no longer valid to guarantee the convergence of the algorithm.

We tackle the design of new fusion rules that take into account the power of this extra noise. These fusion rules are derived from an upper bound on the node-specific estimation cost functions, and result in a new "noisy"-DANSE algorithm, N-DANSE, which is guaranteed to converge to a unique point. The convergence point is optimal when the network has a star topology, which is a special case of a tree topology [3]. Additionally, these fusion rules produce almost no increase in computational complexity compared to the traditional DANSE algorithm.

Finally, numerical simulations show that N-DANSE slightly improves the performance of the DANSE algorithm, where the achievable performance improvement depends on the power of the local errors affecting the fused signals.

References

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