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Fusion in Sensor Networks

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Abstract: Sensor networks are gaining considerable attention nowadays. Pre and post processing of the measured data in such networks is crucial to the conservation of power and communication resources. We address the optimization of these processing requirements in addition to the tradeoff between network parameters.

OCIS codes: (350.2660) Fusion; (040.1880) Detection

The vision of networks of densely distributed sensors brings many advantages over traditional sensing techniques. In addition to improving coverage and special resolution, the perception is that these networks will introduce fundamental improvements in terms of fault tolerance, robustness, and autonomy. These networks are formed of large number of tiny low-cost sensors, which probe the environment and exchange measurements by means of, e.g., optical links [1]. Individually, the sensor nodes have little capabilities, but collaboratively, a dense network of these nodes acts as a single powerful and robust sensor.

Resource limitations in sensor networks lead to fundamental tradeoffs that have to be managed carefully. To conserve the available bandwidth and energy, the collected measurements should be processed (compressed) before being transmitted to other nodes. In a parallel topology, shown in Fig.1, the proper choice of the local compression rules γ_b^n and the remote fusion rule γ^0 determines the overall quality of service (QoS) and, consequently, the required bandwidth and power to meet certain performance specifications. The network in Fig.1 performs a binary detection problem and, hence, its QoS is in terms of the detection performance at the fusion center.

A local compression rule γ_b^n maps a real measurement y_n into a b bit integer u_n. When the measurements are i.i.d, the local compression rules are, simply, scalar quantizers with $2^b - 1$ thresholds. We optimize these thresholds using a cyclic coordinate descent algorithm [2,3]. On the other hand, optimizing the fusion rule γ^0 requires a search over a huge number of possible combinatorial rules. We handle this optimization using the genetic algorithm [3]. Results show that for all of the cases we considered, the algorithm converges to a unique structure shown in Fig.2. This structure can be considered as a generalization of the majority-voting rule for the case when the local decision makers produce soft decisions ($b \geq 1$).

An interesting tradeoff in the design of sensor networks is that of the number of sensors N versus the amount of information b sent per sensor, when the total communication rate is fixed. The result in Fig.3 shows that few high quality sensors can lead to higher QoS in addition to lowering the cost (fewer sensors) under practical assumptions (in this case, high quality quaternary sensors should provide at least 1.5dB more SNR than the binary sensors).

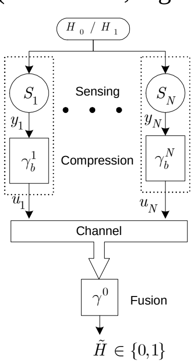

Fig. 1. Parallel fusion network

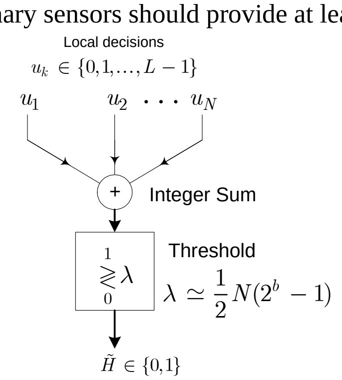

Fig. 2. Majority-like fusion rule

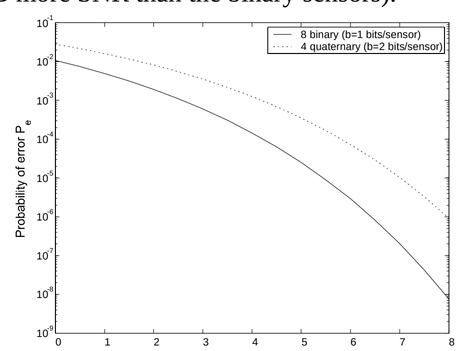

Fig. 3. Soft versus hard sensors

References

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