Distributed Detection over Wireless Sensor Networks using Sparse Active Sensors Estimation

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Next-generation wireless networks require a large number of sensing devices for distributed communications with a simple design for wireless sensor networks (WSNs) and Internet of Things (IoT) applications [1]. In distributed communications, a large number of sensor devices are sensing the event and communicating their decision to a central node, i.e. fusion center. The impact of a number of sensor nodes, the number of antennas at the fusion center and noise distribution are analyzed on the global false alarm and miss detection rate for a WSN in the literature [1, 2]. However, all the sensor nodes are not active[1] at a time in WSN system, which results in a sub-optimal system's performance due to improper resource distribution such as system energy and channel bandwidth. Therefore, a system's performance can be optimized by estimating the active node before the final detection or estimation at the fusion center. After estimating the active nodes in a system, resource distribution can be optimized and results in better performance.

In this paper, we will explore the (active) sensors sparsity to estimate the active sensors at a time by using the compressive sensing framework at the fusion center. Since the active number of sensors are small as compared to the total number of sensors in WSN. After estimating the subset of active sensors and their location in the system, the energy distribution will optimize to enhance the WSN's performance. The energy optimization in the network includes the active number of sensors and their channel gain at the fusion center and individual sensors' local decision quality, i.e. local false and detection probability.

Further, a threshold parameter for hypothesis detection can be optimized using the individual sensor's quality at the fusion center. The proposed distributed WSN system is shown in Fig. 1. Each sensor senses the binary event Θ and decides for the absence ($\mathcal{H}_0$) or presence ($\mathcal{H}_1$) of the event. Hence, Θ belongs to the set hypotheses $\mathcal{H} = \{\mathcal{H}_0, \mathcal{H}_1\}$, and $\mathcal{H}_0$ and $\mathcal{H}_1$ are defined as

$$\begin{aligned} \mathcal{H}_0 &: r_{\mathrm{s}}(t) = n_\Theta(t) \\ \mathcal{H}_1 &: r_{\mathrm{s}}(t) = a_\Theta(t) + n_\Theta(t), \end{aligned} \tag{1}$$

where $r_{\mathrm{s}}(t)$ is the received signal at the sensor node. $a_\Theta(t)$ and $n_\Theta(t)$ are the event signals (such as temperature, humidity) and noise, respectively. Each sensor takes the decision of event Θ and sends their decision[2] to the fusion center using wireless access channel for a global decision of WSN system. Therefore, in the paper, the impact of active sensors' estimation, number of antennas and energy optimization at the fusion center will be analyzed on the global false alarm and detection probability for a WSN system.

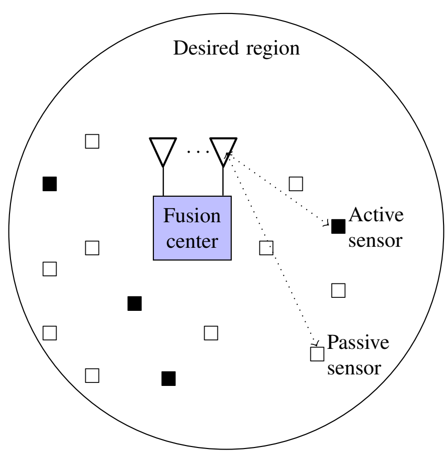

Fig. 1. Block diagram of the proposed method for the distributed detection and estimation.

References

[1] Sanjeev Sharma, Anubha Gupta and Vimal Bhatia, "IR-UWB Sensor Network Using Massive MIMO Decision Fusion: Design and Performance Analysis," *IEEE Sensors Journal,* vol. 18, issue 15, pp. 6290-6302, Aug. 2018.

[2] Sanjeev Sharma, Vimal Bhatia and Anubha Gupta, "Noncoherent IR-UWB Receiver Using Massive Antenna Arrays For Wireless Sensor Networks," *IEEE Sensors Letters,* vol. 2, issue 1, pp. 1-4, Mar. 2018.

[1] Sensing and communicating the local decision to the central node.

[2] In absence or presence, each sensor generates either $d_m = 0$ or $d_m = 1$ respectively based on the signal $r_{\mathrm{s}}(t)$.