Preface

The increasing applications of wireless sensor networks (WSNs) witness the fact that the cooperative effort of sensor nodes can accomplish high-level tasks with sensing, data processing, and communication. Instead of sending the raw data to the fusion centers, sensor nodes execute distributed estimation for practical applications by locally carrying out simple computation and transmitting only the required and/or partially processed data. However, the network-wide information fusion capability and efficiency of the distributed estimation remain largely under-investigated. Moreover, the large-scale of WSNs imposes distinguished challenges on systematic analysis and scalable algorithm design to satisfy fundamental estimation criteria.

In this monograph, we focus on network-wide estimation (and tracking) capability of physical parameters from the system perspective. This problem is of great importance since fundamental guidance on design and deployment of WSNs is vital for practical applications. The metrics of network-wide convergence, unbiasedness, consistency, and optimality are discussed by considering network topology, distributed estimation algorithms, and consensus strategy. It reveals from systematic analysis that proper deployment of sensor nodes and a small number of low-cost relays (without sensing function) can speed up the information fusion and thus improve the estimation capability of WSNs. In Chap. 1, we introduce the spatial distribution of sensor nodes and basic scalable estimation algorithms for WSNs. Brief review of the existing works is given in Chap. 2 to show the collaborative and distributed processing of information with sensor observations and local communications. In Chap. 3, we exploit the consensus based estimation capability for a class of relay assisted sensor networks with asymmetric communication topology. By explicitly taking the functional heterogeneity between sensor nodes and relay nodes into account, a distributed consensus-based unbiased estimation (DCUE) algorithm is proposed. In Chap. 4, for the same relay assisted networks but with symmetric communication topology, we investigate the problem of filter design for mobile target tracking over WSNs. Allowed with process noise of the target and observation noise of sensor nodes, consensus-based distributed filters are designed for sensor nodes to estimate the states (e.g., position and speed) of mobile target. In Chap. 5, it is exploited on how to deploy sensor nodes and relays to satisfy the prescribed distributed estimation capability. A two-step algorithm is presented to meet the requirements of network

connectivity and estimation performance. Finally, we draw conclusions and give a discussion on future work in Chap. 6.

This monograph is hopefully found to be helpful for graduate students and professionals in the fields of networking, computing, and control who are working on the research of topology analysis, sensor fusion, distributed computation and optimization, and especially of distributed estimation and control over WSNs.

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