J Sign Process Syst (2009) 57:381–383
DOI 10.1007/s11265-009-0377-9

GUEST EDITORIAL

Special Issue on "Wireless Sensor Networks"

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Received: 6 May 2009 / Revised: 6 May 2009 / Accepted: 6 May 2009 / Published online: 6 June 2009

Toward the end of the 20th century, the Internet has been able to provide a large number of users with the ability to move diverse forms of information readily and thus has revolutionized business, industry, defense, science, education, research, and human interactions. In the last 10 years, sensor networking combines the technology of modern microelectronic sensors, embedded computational processing systems, and modern computer networking methodology. It is believed that sensor networking in the 21st century will be equally significant by providing measurement of the spatial-temporal physical phenomena around us, leading to a better understanding and utilization of this information in a wide range of applications. Sensor networking will be able to bring a finer-grained and fuller measurement and characterization of the world around us to be processed and communicated, so the decision makers can utilize the information to take actions in near-real-time. The potential applications enabled by SNs include security and surveillance, environmental monitoring and control, target detection and tracking, etc. Wireless sensor networks utilize the extensive networking concepts of ad hoc networks and apply them to specific sensor network scenarios.

This mini-special issue comprises three papers covering three quiet diverse aspects of wireless sensor networks. The first paper, "Lifetime Maximization Based on Coverage and Connectivity in Wireless Sensor Networks," is by T. Zhao et al. They studied the problem of network lifetime maximization for QoS specific information retrieval for the reconstruction of a spatially correlated signal field in a wireless sensor network for two wireless transmission cases. In one case, they assumed there exist single-hop transmissions between sensors and the access point, and in the other case, the measurements are sent to the access point through multi-hop transmissions. To address both of these problems, they formulated the problems using integer programming based on the theories of coverage and connectivity in sensor networks and then derived upper bounds for the network lifetime that provides benchmarks for the performance of suboptimal methods. Several low-complexity suboptimal algorithms for joint node scheduling and data routing were then proposed to approach the performance upper bounds.

The second paper, "Using Heterogeneity to Enhance Random Walk-based Queries," is by M. Zuniga et al. They presented a study of the impact of heterogeneous node connectivity on random walk-based queries. The main contribution of the work is showing that with a small percentage (e.g., 10%) of high-degree nodes in the network and using a simple distributed push-pull mechanism, significant cost savings can be obtained (e.g., between 30% and 70%) depending on the coverage of the high-degree nodes. Their work provides interesting theoretical results for line topologies showing that when cluster-heads have a coverage of k nodes to the right and left and are uniformly distributed, a fraction of 4/5k

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nodes being cluster-heads can offer a reduction in query cost of $O(1-1/k^2)$ by using a simple distributed algorithm. Another important issue is that of delay. One of the drawbacks of random walks is the significant delay that they encounter. In their work, by minimizing the required number of steps on the random walk they are not only able to reduce the cost but also the delay. Hence, heterogeneous networks provide an extra advantage in terms of delay. Also, given the distributed nature of random walks and the proposed push-pull algorithm, cluster-heads can rotate in order to avoid energy depletion, and the only nodes that need to be informed are the neighboring nodes.

The third paper, "An Empirical Study of Collaborative Acoustic Source Localization," is by A. Ali et al. Field biologists use animal sounds to discover the presence of individuals and to study their behavior. Collecting bioacoustic data has traditionally been a difficult and time-consuming process. The recent development of new deployable wirelessly networked acoustic sensor platforms presents opportunities to develop automated tools for bioacoustic field research. In this paper, they implemented both two-dimensional (2-D) and three-dimensional (3-D) Approximate-Maximum-Likelihood (AML) based beamforming source localization algorithms. The 2-D algorithm is used to localize the alarm-calls of marmots on the meadow ground. The 3-D algorithm is used to localize the bird-calls of Acorn Woodpecker and Mexican Antthrush birds situated above the ground. They assessed the performance of these techniques on four field experiments: (1)–(2) two controlled tests of direction-of-arrival (DOA) accuracy using a pre-recorded source signal for 2-D and 3-D analysis, (3) an experiment to detect and localize actual animals in their habitat, with a comparison to ground truth gathered from human observations, and (4) a controlled test of localization experiment using pre-recorded source to enable careful ground truth measurements. Although small arrays in sensor networks yield ambiguities from spatial aliasing of high frequency signals, they showed that these ambiguities are readily eliminated by proper bearing crossings of the DOAs from several platforms. These results show that the AML source localization algorithm deployed on several self-localizing wirelessly networked acoustic sensing platforms can be used in a practical manner to localize actual animals in their natural habitat.

Acknowledgment The guest co-editors would like to thank Prof. S. Y. Kung and the editorial staff of the journal for various assistance in the completion of this Special Issue.

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