

Sensor Network Lifetime Maximization Via Sensor Trees Construction and Scheduling

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ABSTRACT

In this paper we consider state estimation carried over a sensor network. A fusion center forms a local multi-hop tree of sensors and fuses the data into a state estimate. A set of sensor trees with desired properties is constructed, and those sensor trees are scheduled in such a way that the network lifetime is maximized. The sensor tree construction and scheduling algorithms are shown to have low polynomial time complexity, which leads to efficient implementation in practice. The scheduling algorithm is also shown to return the optimal solution. Examples are provided to demonstrate the algorithms.

General Terms

Wireless Sensor Networks, Estimation and Control, Scheduling

Keywords

Estimation, Kalman Filtering, Sensor Tree Construction,

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Sensor Tree Scheduling

1. INTRODUCTION

Wireless sensor networks have attracted much attention in the past few years and this area of research brings together researchers from computer science, communication, control, etc [1]. A typical wireless sensor network consists of a large number of sensor nodes and some base stations [2]. Sensor nodes are usually battery powered and have limited processing capabilities. They interact with the physical world and collect information of interest, e.g, temperature, humidity, pressure, air density, etc. Depending on the Media Access Control (MAC) and routing protocols, as well as the available resources (network bandwidth, node energy, etc), the collected data are transmitted to their final destination, usually a fusion center, at appropriate times.

Sensor networks have a wide range of applications, including environment and habitat monitoring, health care, home and office automation and traffic control [3]. Although tremendous progress has been made in the past few years in making sensor network an enabling technology, many challenging problems remain to be solved, e.g, network topology control and routing, collaborative signal collection and information processing, and synchronization.

In particular any practical design must fully consider the constraints posed by the limited processing capability and energy supply of each individual sensor. We investigated such constraints in [4] by looking at LQG control over a wireless sensor network. We presented a sensor tree reconfiguration algorithm to meet a specified level of control performance in such a way that the total energy usage of the active sensor nodes in the tree is minimized.

However when a sensor node is not a leaf node, it not only needs to send a measurement data packet, but also needs to receive and forward data packets from its child nodes. As receiving a packet also costs a considerable amount of energy [3], in general those sensor nodes that are closer to the fusion center consume more energy than those that are far away. This is usually called the *funneling effect* in sen-

