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Transmission Power Scheduling and Control Co-design for Wireless Sensor Networks
Shixi Wen\*, Ge Guo, Bo Chen, Xiue Gao

Abstract: This paper discusses transmission power scheduling and control co-design in wireless sensor networks (WSNs) under communication energy constraints, in which the dynamics of all mobile sensor nodes (MSNs) are assumed to be nonlinear. A most regular code sequence (MRCS) is introduced as the transmission power scheduling policy to automatically allocate the transmission power levels to MSNs thereby adhering to the given communication energy budget. The effects of the different transmission power levels on data transmission is explicitly characterized in this paper. By using a stochastic system analysis approach and average dwell time technique, a framework for the transmission power scheduling and control co-design is established. The control co-design algorithm is proposed to simultaneously determine the gain of the sampled-data feedback controller and the parameters of the generated MRCS. A numerical simulation is conducted to verify the effectiveness of the proposed algorithm.

Key words: Wireless sensor networks, transmission power scheduling, communication energy constraints, most regular code sequence (MRCS), control co-design.

1. Introduction

Wireless sensor networks (WSNs) have recently drawn considerable attention due to their widespread applications in environmental sensing, military surveillance and structural health monitoring [20], [22], [28], [34]. In contrast to traditional wired sensors, WSNs have remarkable advantages e.g., low cost, easy installation and maintenance, improved flexibility and reliability. Consequently, significant research has been conducted on WSNs regarding, distributed estimation/filtering [19], [21], [30], [14], [15], [18] location and tracking [12], [35], optimal coverage [27], [3], and consensus problems [9], [10], [39], [40].

In a WSN, a group of mobile sensor nodes (MSNs) is usually distributed in a wide area and each MSN is powered by a battery to receive and send data. In general, the battery has limited capacity, and its replacement is inconvenient. Therefore, one important problem regarding WSNs is how to significantly reduce the consumption of communication energy to prolong the life of MSNs. Various efficient schemes have been proposed in literature. To name just a few, a sensor technique was investigated [31] to harvest ambient energy, e.g., solar energy, vibration energy and wind energy. In [34], the deployment of multiple mobile charging vehicles was studied. Wireless energy transfer was employed to charge the sensors in a large-scale WSN. For saving kinetic energy of the distributed MSNs, the sampled-data cooperative control technique (SCCT) was used in [17] to efficiently coordinate MSNs. The logic zero-order hold was proposed in [42] to actively discard the disordered sampled-data packets of the SCCT. A recent investigation on event-triggered control and filtering for network systems can be found in [11] and [41], respectively. A quantization technique was introduced in [6] to save energy by compressing the packet size. Further, in [36] and [37] multi-rate schemes were adopted to reduce energy consumption. By applying those, the sensors can estimate the states at a faster time scale and exchange information with neighbors at a slower time scale. The authors in

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