Energy Efficient Distributed Target Tracking Algorithm in Underwater Wireless Sensor Networks

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ABSTRACT

The growing interests in underwater wireless sensor networks (UWSNs) for a wide variety of purposes from Tsunami monitoring to commercial oilfield exploration projects have been encouraging. This paper deals with the problem of accurately tracking a single target moving through UWSNs employing acoustic sensors. This paper addresses the issues of estimating the target position, improving energy efficiency by applying a Kalman filter in a distributed architecture. Each underwater wireless sensor node composing the UWSNs is battery-powered, so the energy conservation problem is a critical issue. This paper provides an algorithm which increases energy efficiency of each sensor through a wake-up/sleep (WuS) and a valid measurement selecting (VMS) scheme. Simulation results illustrate the performance of the tracking filter according to the sensor node displacement and sensor detecting area.

KEY WORDS: UWSN, Kalman filter, Wake-up/Sleep (WuS) scheme, Valid Measurement Selecting (VMS) scheme.

INTRODUCTION

Advances in micro electromechanical systems (MEMS) and wireless technologies have allowed for the emergence of inexpensive micro-sensors with embedded processing and communication capabilities (Chong, Zhao, Mori, and Kumar, 2003). Sensor networks consist of many of these micro-sensors communicating with one another over wireless links. Wireless sensor networks (WSNs) are emerging technology for monitoring physical world with a densely deployed network of sensor nodes. The main advantages of WSNs include its low cost, rapid deployment, self-organization, and fault tolerance. It can be used in a variety of applications, such as environment monitoring, traffic monitoring in intelligent transportation systems, industrial sensing and diagnostics, healthcare, navigation and control of mobile robots, and military surveillance.

One of the main constraints for WSNs is energy. It typically is impractical to replace the battery on each sensor node, so the lifetime of the network is tied to the battery life. The authors in (Brooks, Ramanathan, and Sayeed, 2003) argue for the need to study the problem of energy-aware target tracking for wireless sensor networks.

One approach to target tracking is to use a centralized architecture, where all sensor measurements are sent to a central processing station. However, this architecture demands significant bandwidth for communication of every node’s sensor measurements, which can put a strain on the node battery lifetime (Chong, Zhao, Mori, and Kumar, 2003). Other issues with a centralized architecture are the lack of robustness and reliability.

To reduce the communication burden, a distributed architecture is preferred for wireless sensor networks. In a distributed architecture, a sensor node is chosen near the target position as a processing node, and a subset of local sensors in the network is chosen to collect sensor data while the remaining sensors are placed in a power-saving sleep mode. An added advantage to using a distributed architecture is its robustness to network changes and node failures (Chong and Kumar, 2003).

In this paper, we look at an example of a distributed tracking algorithm for a moving target through UWSNs. We consider a single target tracking problem only. Extension to the multiple target tracking problem is not considered. We address the issues of estimating target position and improving energy efficiency by applying a Kalman filter in a distributed architecture. To estimate the states of the target, we propose the energy efficient tracking algorithm using the WuS and VMS scheme for a distributed target tracking.

The rest of the paper proceeds as follows. Section II describes the problem by defining the target motion models, as well as the measurement model of the UWSNs of acoustic sensors. Section III sets up the Kalman filtering framework that will be used for estimating the state of the target and describes a distributed target tracking architecture. In section IV, the energy efficient tracking algorithms, using the WuS and VMS scheme, are presented for distributed target tracking. In section V, simulation