Accepted Manuscript

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PII: S1084-8045(18)30263-7

DOI: 10.1016/j.jnca.2018.08.006

Reference: YJNCA 2190

To appear in: *Journal of Network and Computer Applications*

Received Date: 2 March 2018

Revised Date: 3 July 2018

Accepted Date: 14 August 2018

Please cite this article as: Lu, X., Liu, J., Qi, W., Dai, Q., Multiple-target tracking based on compressed sensing in the Internet of Things, *Journal of Network and Computer Applications* (2018), doi: 10.1016/j.jnca.2018.08.006.

Multiple-Target Tracking based on Compressed Sensing in the Internet of Things

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Abstract: An algorithm based on compressed sensing for tracking multiple targets in the Internet of Things (IoT) is proposed in this study. First, we build a sparse representation of the changes in the sampling signal caused by nodes to multiple targets in a monitored area. Second, we observe the sampling of the sensing signals by nodes to mobile targets and reconstruct the sampling subtraction data. Third, we use sampling subtraction, which is extended by a background subtraction technique in video target tracking, to obtain useful tracking data with sampling subtraction data and to locate the mobile targets. Simulation results show that the proposed algorithm recovers the sensing signal with sparse sampling subtraction data, accurately locates multiple targets, significantly reduces network communication traffic, and improves the energy efficiency of the system with the sparse sampling strategy.

Keywords: Internet of Things; target tracking; compressed sensing; sampling subtraction

1. Introduction

The network application for target tracking is one of the important application forms of the Internet of Things (IoT) [1]. Sensor nodes in IoT are small and convenient for deploying, tracking, and hiding. Dense network nodes can accurately sense and track mobile targets and display the movement of targets in detail [2] [3]. With the synchronous monitoring of multiple nodes and the combination of distributed data processing and multiple-node synergy, mobile targets can be found immediately, and real-time target tracking can be improved. Disabled or newly added nodes can be automatically configured and tolerated even in a severe environment, thereby creating reliable, fault-tolerant, and robust target tracking.

To track mobile targets, we should circularly detect the location of a target in a network. Currently, the location technique based on received signal strength (RSS) has a wide application [4]. It is less expensive, does not require hardware, and is easily obtained compared with techniques based on Time-of-Arrival, Time-Difference-of-Arrival, and Angle-of-Arrival [5]. The algorithm proposed in this study is exactly based on the location technique of RSS.

Many wireless sensor nodes of IoT are generally powered by batteries and deployed in areas that cannot be easily accessed. Moreover, replacing or recharging batteries is difficult because of the limited energy and capacity of nodes. [6]. Therefore, the network lifetime is determined by the energy consumption of sensor nodes, and energy-efficient network protocols should be designed. Our research is theoretically based on compressed sensing theory [7], which can be applied to multiple-mobile-target tracking in monitored areas with various shapes. Compressed sensing, also called compressed sampling or sparse sampling, is a new sampling theory, but it is a controversial research topic in electronic engineering, especially in signal processing. Compressed sensing theory has raised wide concern in the academe and the industry, especially in information theory, image processing, earth sciences, optics/microwave imaging, pattern recognition, wireless communication, atmospheric sciences, and geology. Compressed sensing can be used to reconstruct the original signal by sampling a small number of signals to achieve “Hearing without Listening” [8], and its sampling rate is much lower than that of traditional Nyquist/Shannon sampling theorem [9]. Compressed sensing is suitable for the information collection system of a sensing layer in IoT because sensor nodes can obtain a small number of sampling data by simply sensing and sending data to a sink node, which performs data reconstruction in large-scale calculation with its unlimited energy and calculation ability. In this manner, the amount of sampling data and the transmission of energy-limited sensor nodes are reduced significantly. Thus, the energy consumption of a network can be decreased, and its lifetime can be prolonged.

The subsequent parts of this paper are structured as follows. Section 2 provides a review of related literature. Section 3 introduces the network model. Section 4 discusses the theoretical basis for this work. Section 5 describes the proposed algorithm for multiple target tracking. Section 6 explains the simulation setup and shows the performance analysis. Section 7 presents our conclusion.

2. Related works

Multiple-target tracking has been widely explored in the field of IoT. Existing studies have focused on target prediction and node scheduling. Distributed filtering algorithms are commonly used in target prediction. Olfati-Saber and Jalalkmali [10] proposed a distributed mobile sensor network cooperative target tracking theory framework. Two types of linear and nonlinear random target tracking are obtained on the basis of a continuous Kalman filtering algorithm. Lin et al. [11] divided a network into clusters, and target detection probability is derived from the target state equation via cluster head nodes. An extended