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Generating Event Sensor Readings Using Spatial Correlations and a Graph Sensor AdVersarial Model for Energy Saving in IoT: GSAVES

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***Abstract*—This work targets a comprehensive model enabling energy-constrained IoT (Internet of Things) sensor devices to be inactive for extended periods while estimating their readings of real-time events. Although events seem semantically uncoupled, they are usually spatially and temporally related. We propose GSAVES (Graph Sensor AdVersarial for Energy Saving), which uses readings from active devices and spatial correlations to generate the missing data due to sensor inactivity. The missing readings are generated with Graph Convolutional Network (GCN) that learns embeddings from data and the graph structure. GSAVES is evaluated against four state-of-the-art solutions using three network sizes and four performance metrics. The results demonstrate the efficiency of GSAVES for providing the best balance between the considered metrics, outperforming all the solutions in reducing energy consumption and improving accuracy.**

I. Introduction

Increased network longevity on the Internet of Things (IoT) has concerned researchers, network designers, developers, and hardware manufacturers alike [1]. IoT devices are envisioned with wireless charging and energy harvesting capabilities [2]. Nonetheless, these technologies only satisfied a limited set of applications but not real-time and event-based applications such as occupancy monitoring in smart buildings, road traffic monitoring, etc. This paper considers event-based applications and addresses network lifetime maximization by exploiting the spatiotemporal characteristics of sensory data without impacting detection accuracy. The proposed model attempts to accurately estimate readings of sleeping sensors after learning correlations in sensor readings. The sensors are turned off dynamically to preserve energy (both from sensing and communicating). Optimal sensing coverage may be desired in many applications [3]. Nevertheless, monitoring the entire field is not always required, particularly for event detection, as events occur during brief periods and can be detected by more than one sensor. Therefore, sensors can mutually cover one another, and sensor values can be generated and predicted with a correlation learning model. The trained model replaces the sensors, reducing thus the energy those sensors consume for sensing and communications. There are two categories of correlations, temporal vs. spatial. The former consists of turning ”off” all the sensors simultaneously and then predicting future values from the last readings using correlations (temporal prediction). The latter consists in turning part of the network ”on” and deducing the values of the remaining part using correlation sensors (spatial prediction).

[4] was based on the first approach and used an LSTM sequence model that learns temporal correlations to predict the sensors' values. A reinforcement learning model was also used, which orchestrates the activation/deactivation of the sensors. The shortcoming of this approach is the requirement of a significant amount of data and training time. Therefore, the current paper explores the second approach while targeting event-based applications. Some machine-learning models based on this approach have already been proposed [5], [6]. However, most of these solutions aim to reduce energy consumption only for some sensors while leaving it high for the rest of the network, which may affect the overall network's lifetime and performance. Furthermore, such solutions save the energy of nodes characterized as less-informative while putting the load on the most indicative ones. This paper follows a different approach, allowing the entire network to reduce its energy dynamically and in a balanced way.

The proposed approach operates on the data collector. We adopt a simple distributed sleep scheduling mechanism at the sensor level to avoid additional communication or computation overhead resulting from wake-up message exchange and sleep period calculation. At the data collector level (cloud, base station, edge), we propose a model (the generator) that generates the missing data of sleeping

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