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Event Localization in the Internet of Things Environment

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Abstract

The Internet of Things environment supports the device-to-device communication. These devices respond to the events generated to serve various applications. The processing of these applications need reliable data dissemination to achieve accuracy in data distribution. In such cases, localization of events occurring in the environment becomes most crucial. Moreover, in heterogeneous IoT scenario, event localization may help in real time service delivery. This paper proposes a Direction of Arrival based event localization method for IoT environment. The proposed work uses auto-regression modeling to estimate the location of events. The efficacy of the proposed algorithm is evaluated in IoT based environment.

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1. Introduction

The Internet of Things (IoT) is an application specific network. It constitutes of a huge number of devices which are computationally more powerful. These devices may be a sensor device or an IoT device [1]. The distributed computing scheme acts as an effective strategy in processing of applications in such an environment due to the scattering of devices in the region. The communication performance in such a network gets affected by the energy consumption of devices. In such a scenario, there are different applications existing such as home automation [2], traffic control [3], surveillance [4], disaster relief [5] and health care [6]. Typically, the different types of events may emerge at different intervals of time and at various locations. These events need to be processed in real time, irrespective of the applications. The effectiveness of an event driven system is complied by the use of real time service delivery in the network. Such services use the information for event declaration which needs generic consensus [7]. In this context, the event reporting may be frequent or rarer in occurrence and regarded as an effective strategy to exemplify the quality of information in IoT environment. In this view, the localization of event becomes crucial to support efficient event response time and reliability of data dissemination in such an environment.

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In IoT network, the deployed devices may or may not be intelligent. The events, as and when occur, are detected and communicated among the sensor devices and the IoT devices to further process them. However, for localizing events, sensed information is required from spatially dispersed devices in the region. Also, the devices may be deployed in such a way that they form different topologies with or without the line of sight conditions. Moreover, the events may occur at anywhere and at anytime, thus, prompting the devices to receive the signals coming from different directions. In this context, this paper focuses on the event localization using Direction of Arrival (DoA) based estimation technique.

In the past, many methods have been reported in literature which discuss the need of DoA estimation [8, 9, 10, 11] defined and used in signal processing applications. The estimation is based on the fact that there is a one-to-one relationship between the direction of signal and the associated steering vector [11]. The DoA estimation is classified based on parametric and non parametric characteristics of a signal [12]. The parametric estimation technique is further classified into subspace based [11], auto-regression (AR) based [13] and model fitting based [10] methods. Similarly, the non parametric DoA estimation uses either high resolution [9] or low resolution methods [14]. In practice, there are an unknown number of signals impinging on the array of devices simultaneously. Also, each signal has unknown direction and amplitude, due to which, the estimation of direction becomes difficult. It becomes even more challenging with the introduction of noise in real time IoT environment. In such cases, the high resolution methods are more prominent due to their focus on results with more precision. One of the high resolution parametric estimation techniques for direction of arrival uses the auto-regression (AR) method. It achieves a much lower root mean square error (RMSE) in DoA estimation and angular spread estimation [15]. Furthermore, the lower computation complexity of AR method suggests its effectiveness over other parametric approaches.

In this paper, we propose an event localization technique in the IoT environment using DoA method. It estimates the direction of arrival, angular spread and absolute location of the events occurring in the network scenario. The novelty of the proposed work is that it estimates the event location based on AR method for multiple distributed events to find their absolute location, where IoT network is setup for a particular application. Moreover, in IoT scenario, the monitoring of remote locations poses the challenge of communication delay and cost. In such cases, the event localization becomes very crucial and, thus, addressed in this paper. The rest of the paper is organized as follows. Section 2 presents the proposed event localization algorithm based on DoA estimation technique. Section 3 discusses the efficacy of the proposed work by providing analysis of the results obtained, followed by the conclusion of paper in section 4.

2. Event Localization Algorithm

In this section, we propose the event localization algorithm based on the direction of arrival technique. The purpose of the proposed algorithm is to estimate the location of events by utilizing the nominal DoA and angular spread with respect to the distributed devices in the region. Further, these two parameters are used to estimate the absolute location of the events. In IoT environment, a large number of devices are scattered in the plane. Since, the event localization needs uniform feed from the devices deployed in the terrain, we assume a uniform linear array of devices deployed in the terrain. Let us assume that there are n devices deployed in the region of interest given by $S = \{S_1, S_2, S_3, \dots, S_n\}$, separated by a uniform distance d'' . The location of the deployed devices are calculated using our earlier proposed localization method [1] for devices in the IoT framework. Let us suppose that $(X, Y) = \{(x_1, y_1), (x_2, y_2), (x_3, y_3), \dots, (x_n, y_n)\}$ denotes the estimated location of n devices. Also, assume that the angle dispersed by n devices at origin O is given by $\theta = \{\theta_1, \theta_2, \theta_3, \dots, \theta_n\}$. Let the set $D' = \{d'_1, d'_2, d'_3, \dots, d'_n\}$ represents the distance of i^{th} device from origin O . Further, it is assumed that multiple events are occurring in the region. These events may occur at different times and at different locations. The location information of the event E needs to be known so as to deliver the relevant services reliably for further processing.

First, the distance of an event occurring in the region of interest is calculated from each deployed device. As and when an event occurs, the devices in the region gets notified through reception of signals from it. Let us suppose that the signals specified by $F = \{f_1, f_2, f_3, \dots, f_n\}$ are received by n different devices from the event. Due to the obstructions and reflections observed in signal propagation, the Friis equation [16] is used to estimate the distance (d),

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