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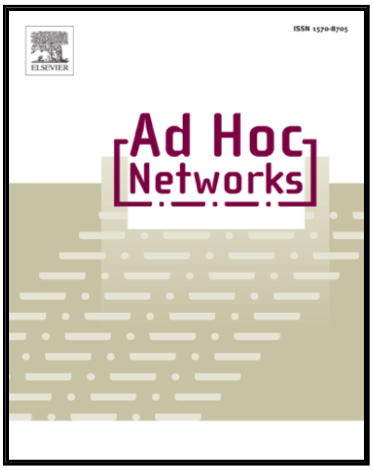

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Path Planning for Mobile-Anchor Based Wireless Sensor Network Localization: Static and Dynamic Schemes

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Abstract

In wireless sensor networks, node locations are required for many applications. Usually, anchors with known positions are employed for localization. Sensor positions can be estimated more efficiently by using mobile anchors (MAs). Finding the best MA trajectory is an important problem in this context. Various path planning algorithms are proposed to localize as many sensors as possible by following the shortest path with minimum number of anchors. In this paper, path planning algorithms for MA assisted localization are proposed for both static and dynamic schemes. These approaches use MAs by stopping at minimum number of nodes to cover the monitoring area with shortest path length. A novel node localization algorithm based on alternating minimization is proposed. The performances of the proposed path planning algorithms are compared with previous approaches through simulations. The results show that more sensors are localized with less anchors in a shorter path and time for both schemes.

Keywords: Wireless sensor network localization, mobile anchor, path planning, alternating minimization algorithm.

1. Introduction

Wireless sensor networks (WSNs) contain randomly distributed sensors with limited battery and processing capability [1]. In a WSN, sensors are able to collect physical data from the environment for target tracking, surveillance and emergency responding [2]. The sensor positions are usually unknown and have to be found for mapping the network area. Estimating the physical coordinates of a sensor node or the special relationships among objects is known as localization [3]. To localize the sensors, some known positions are required in a WSN. These are called anchors (or beacons) and their locations are determined by Global Positioning System (GPS) measurements [4]. The sensors are localized by using anchor positions for various WSN schemes. Anchor nodes with known positions are required to localize sensors. Usually GPS is used for anchor position identification [4]. Sensors are localized using the anchor positions and the distances between the anchor and sensor nodes.

WSN localization can be classified as mobile-anchor and static-anchor based schemes. In this paper, mobile-anchor and static-sensor scenario is considered similar to [5]. In WSNs, anchor positions play a key role for improving the localization accuracy. However, increasing the number of anchors increases the cost of localization. Moreover, in static anchor scenarios, all anchors become useless after the localization. Hence, using a mobile anchor (MA) with the ability to broadcast its position decreases the cost of the process [6]. In MA based scheme, a MA creates anchor nodes on a path to localize the sensors. The impact of a MA path on the quality of anchor positions is critical for localization accuracy. There are various algorithms for path decision, namely mobility models and path planning [4]. In this paper, static and dynamic path planning algorithms are considered. The difference between the static and dynamic case is that the static path planning is done prior to the localization and cannot be changed during the process. However, the dynamic path can be modified with the demand of user or the sensor distribution. For instance, the number of anchors required for localization and the trajectory can be changed in real time [7].

In the proposed static approach, the path is determined based on trilateration. It achieves the same localization performance as other trilateration based algorithms, such as [8] and [9], but with less anchors and a shorter path. Hence, the proposed static algorithm is an energy efficient approach.

In this paper, the proposed dynamic approach has certain advantages compared to previous methods. The proposed algorithm has two stages where the monitoring area is covered in a regular grid to identify the grids with sensors. Hence, the MA does not revisit the sensor free grids in the second stage. This decreases the path length and the number of anchor nodes compared to known techniques in the literature [6], [10], [11].

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