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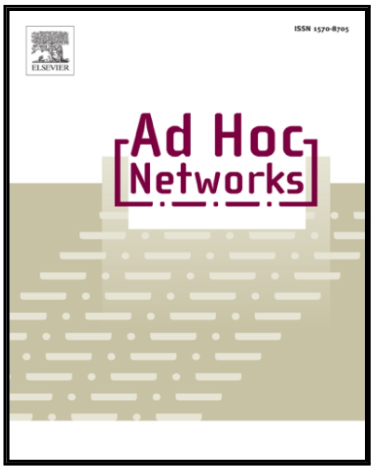

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Cooperative Method for Wireless Sensor Network Localization

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Abstract

In order to obtain an efficient wireless sensor network localization, several enhancements based on the decentralized approach are proposed. These features can be used in the cases when multiple distance measurements are used as input, where each node iteratively updates its estimated position using a maximum likelihood estimation method based on the previously estimated positions of its neighbors. Three novel features are introduced. First, a *backbone* is constructed, that is, a subset of nodes that are intermediaries between multiple beacon nodes, which guides the localization process of the other (non-backbone) nodes. Second, the space is perturbed more often during the earlier time steps to avoid reaching poor local minima in some cases regarding the localization optimization function. Third, for better localization of the non-backbone (or peripheral) nodes and avoidance of the rigidity problem, 2-hop neighboring distances are approximated. The introduced features are incorporated in a range-based algorithm that is fully distributed, shows good performance, and is scalable to arbitrary network size.

1. Introduction

Wireless sensor networks (WSNs) have recently attracted considerable research interest by providing unprecedented opportunities for monitoring and controlling homes, cities, and the environment. They consist of spatially distributed smart autonomous sensors, networked through wireless links and deployed in large numbers. Self-localization capability is a highly desirable characteristic of wireless sensor networks. Sensor network localization algorithms estimate the locations of sensors with initially unknown location information by using knowledge of the positions of a few sensors and inter-sensor measurements such as distance and bearing measurements. Sensors with known location information are called beacons or anchors and their locations can be obtained by using a global positioning system (GPS), or by installing them at points with known coordinates.

Many approaches for WSN localization have been studied in the literature. Overviews of WSN localization techniques are presented in [1, 2, 3, 4]. For a survey of localization in mobile WSNs, we refer to [5]. The spatio-temporal cooperation for localization and navigation is extensively studied in [6, 7].

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1.1. Previous work

Localization techniques can be broadly classified into two categories: range-based and range-free. In large-scale WSNs, where signal range is limited, range-based schemes typically require a lot of beacon nodes to produce accurate results. On the other hand, range-free schemes estimate inter-node distances based on hop count information, thus all target nodes can be localized with fewer beacon nodes. Range-free techniques are those where node position estimation is not based on the distance estimation between nodes but on the solution to heuristic or optimization problems with a decentralized characteristic. The typical range-free algorithms include Centroid [8], CPE (Convex Position Estimation) [9], and DV-hop (Distance Vector-hop) [10]. Centroid and CPE are simple, having low complexity, but they require a normal node to have at least three neighboring beacons. DV-hop algorithm can handle the case where a normal node has less than three neighbor beacons.

Since the quality of localization is easily affected by node density and network conditions, range-free approaches typically provide imprecise estimation of node locations. Range-based approaches measure the Euclidean distances among the nodes with certain ranging techniques and locate the nodes using geometric methods, such as time of arrival (TOA), time difference of arrival (TDOA), and angle of arrival (AOA).

Here we focus on range-based designs for sparse networks. Several range-based algorithms that address the

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