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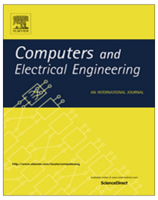

An improved multihop-based localization algorithm for wireless sensor network using learning approach [☆]

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ABSTRACT

Multihop range-free localization methods could obtain relatively reasonable location estimation in the isotropic network; however, during the practical application, it is often affected by various anisotropic factors such as the radio irregularity and barriers, which can significantly reduce its performance. In this paper, we propose a new approach for multihop localization in wireless sensor network based on nonlinear mapping and learning algorithm. The proposed method is simple, efficient, higher accuracy and no need to set complex parameter in that only hop-counts information and position information of the beacons are used for the localization. The proposed approach is composed of two steps: firstly, this algorithm uses kernel function to define the connectivity information (hop-counts) between nodes, then, learning method is used to guide and build the inter-node localization model; secondly, the hop-counts between the unknown nodes and beacons are used to estimate the coordinate of unknown nodes. We evaluate our algorithm under various anisotropic network and real environment, and analyze its performance. We also compare our approach with several available advanced approaches, and demonstrate the superior performance of our proposed algorithm in terms of location estimation adaptability.

1. Introduction

In Wireless Sensor Network (WSN), location information of the event is usually the precondition for its application, and related literatures show that about 80% contextual information is related to the location [1]. We can acquire the location information of event occurrence through Global Position System (GPS)/BeiDou Navigation Satellite System (BDS) devices; however, equipping one GPS/BDS for each sensor node is too expensive and infeasible for a large-scale wireless network. Instead, an economic and feasible approach is to equip GPS/BDS only for a small number of sensors (also called known sensors or beacons), thus their locations can be gathered relatively easily while the locations of the remaining sensors are unknown. Therefore, we need to propose some localization technique or algorithms to estimate the physical location of unknown sensors, for performing some specific tasks through collecting information from the whole network.

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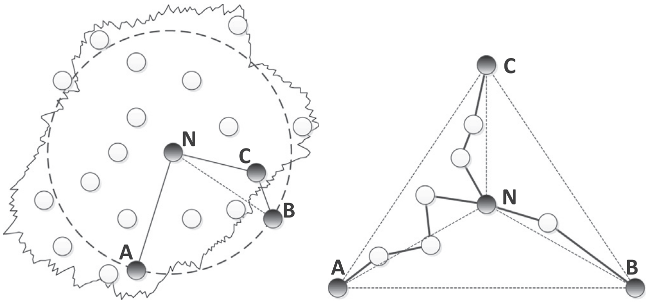
Usually, localization algorithms can be divided into two classes: range-based and range-free [2,3]. The range-based localization approaches adopt ranging techniques and use internode distance measurements to calculate the locations of nodes. These approaches have relatively higher precision for a short range, but have higher cost and need rigid requirement on hardwares. Thus, they are not suitable for large-scale deployment. Taking into consideration practical cost and energy consumption, simple and feasible range-free methods are normally applied in practice. On the other hand, range-free schemes do not need additional hardware support but make use of connectivity, multi-hop routing and other information between nodes to estimate nodes location. Research of range-free mainly focuses on hop-count estimation method, which is based on an assumption that there is certain function mapping relation between physical distance and smallest hop-counts for each pair of sensor nodes. However, sensor nodes are deployed in complex area, so the mapping function no longer holds. As a result, using the multihop-based algorithm under this scenario will bring a large localization error. One reason leads to the low accuracy of multihop-based approach is the ambiguity problem of hop-counts and distances [4,5]. Those nodes with the same physical distances to a node mostly will not have the same hop-counts. As shown in Fig. 1(a), in complex environments, the radio ranges of nodes are often of irregular shape. The physical distances from node ***A*** and node ***B*** to node ***N*** are exactly the same. From node ***A*** to node ***N***, the hop count is one, while from node ***B*** to node ***N***, the route has to go through node ***C***. Fig. 1(b) shows that the distances from node ***A***, ***B*** and ***C*** to node ***N*** are all the same. However, owing to uneven deployment, the hop-counts between them are quite different. When the above situation happens, using hop-distance (average physical distance of one hop multiplies hop-counts) to represent physical distance may inevitably reduce the localization performance.

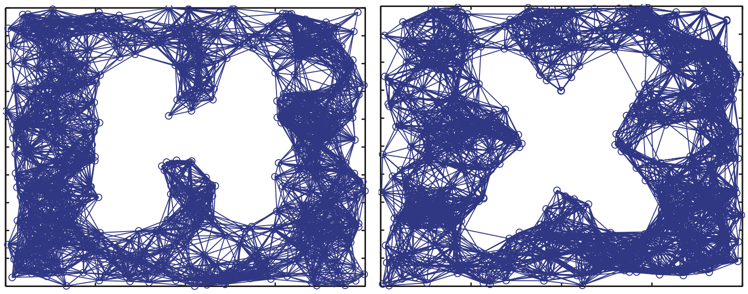
The non-convex region assumption [4] is another problem of the low accuracy of multihop-based approach. That is, these schemes often (implicitly) assume that all nodes are uniformly distributed in the whole deployed region. In practice, the large-scale deployment of nodes with a random manner (e.g., dropped by aircraft) hardly guarantees such a convex region. As shown in Fig. 2, obstructions or dead zones in the deployment area turn the convex network topology into non-convex network with holes. As for this, the original straight communication patch is bended along the inner border of the non-convex area, increasing hop-counts, and measurement errors between nodes.

This paper studies how to solve the above two problems in these localization schemes, and how to improve accuracy of multihop range-free localization. On this basis, we proposed a novel multihop range-free localization algorithm, called Kernel Ridge Regression-Multihop Localization (KRR-ML). KRR-ML algorithm mainly consists of two parts: First, it make uses of the kernel method to measure the similarity between hop-counts and physical distance to avoid the nonlinear characteristics among them. Soon after, it figures out the mapping relationship between hop-counts and physical distance using the regression method. Second, each unknown node find its own location using this mapping relationship and hop-counts with



(a) (b)

Fig. 1. Hop-counts and distances ambiguity network.



(a)Networkswith"H"hole (b)Networkswith"X"hole

Fig. 2. Non-convex topology network.