Sensor Localization with Ring Overlapping Based on Comparison of Received Signal Strength Indicator

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***Abstract*—**

Sensor localization has become an essential requirement for realistic applications over Wireless Sensor Networks (WSNs). Radio propagation irregularity and the stringent constraint on hardware cost, however, make localization in WSNs very challenging. Range-free localizations are more appealing for range-based ones, since it does not depend on received signal strength to estimate distance and thus needs simple and cheap hardware only. In this paper, we propose a ring-overlapping, range-free approach using Ring Overlapping based on Comparison of Received Signal Strength Indicator (ROCRSSI). Simulation results have verified the high estimation accuracy achieved with ROCRSSI.

***Key Words*—**

Range-Free Localization, Wireless Sensor Networks

I. Introduction and Background

Wireless Sensor Networks(WSNs) become the current hot spot of networking area and have been used for various applications, such as habitant monitoring, environment monitoring, and target tracking. Location information plays a crucial role in understanding the application context in WSNs [5] [6], and many localization algorithms for WSNs have been proposed to provide per-node location information. They can be divided into two categories: ranged-based methods [1] [3] and ranged-free methods [2] [7] [4]. Range-based localization depends on the assumption that the absolute distance between a sender and a receiver can be estimated by received signal strength or by the time-of-flight of communication signal from the sender to the receiver. The accuracy of such estimation, however, is subject to the transmission medium and surrounding environment and usually relies on complex hardware [8]. In contrast, range-free localization never tries to estimate the absolute point-to-point distance based on received signal strength. As such, the design of hardware can be greatly simplified, making rang-free localization very appealing for WSNs.

In this paper, we propose another range-free localization approach, Ring Overlapping based on Comparison of Received Signal Strength Indicator (ROCRSSI), that uses ring-overlapping to estimate nodes' location. This approach has the following prominent features. First, it does not require sensor nodes to send out control messages, and the communication cost is light and on anchor nodes only. Second, ring-overlapping, compared to triangle-overlapping in APIT [4] that is demonstrated to perform best for randomly deployed WSNs among existing range-free localization approaches, generates small intersection area and results in more accurate location estimation. Finally, the proposed ring-overlapping method is robust under irregular radio propagation patterns.

II. Ring Overlapping based on Comparison of Received Signal Strength Indicator (ROCRSSI)

A. Introduction of ROCRSSI

The motivation of ROCRSSI is to get accurate estimation and reduce communication overhead with small number of anchors. Anchors, which is generally required to deploy with sensor nodes by most of range-free localization methods [2] [7] [4], are those nodes who know their locations and usually have larger transmission power than normal sensor nodes. The general idea of ROCRSSI is that each sensor node uses a series of overlapping rings to narrow down the possible area in which it resides. As the example shown in Fig. 1(b), if S can determine that its distance to A is larger than the distance between A and B, but less than the distance between A and C, it can conclude that it falls within the ring center at A with the inner radius equal to the distance between A and B and the outer radius equal to the distance between A and C. Similarly, S can figure out another ring centered at anchor B, and a circle centered at anchor C. Then it calculates the intersection area of these rings (or circles) and takes the gravity of this area as its estimated location.

The rings can be generated by comparison of the signal strength a sensor node receives from a specific anchor and the signal strength other anchors receive from the same anchor. For example, in Fig. 1(a), assume that A, B, and C are three anchor nodes and S is a sensor node. Assume that anchor A sends out beacon messages and the signal strength received by anchor B, anchor C, and sensor S is $RSSI_{AB}$, $RSSI_{AC}$, and $RSSI_{AS}$ respectively. If $RSSI_{AB} > RSSI_{AS} > RSSI_{AC}$, then S is likely to fall within the shadowed ring area if anchor B, anchor C, and node S are roughly in the same direction from anchor A. Since ROCRSSI does not try to map the received signal strength to absolute point-to-point distance, it belongs to range-free localization approaches. Notably, ROCRSSI only compares the relative strength of RSSI and does not depend on absolute RSSI values.

The correctness of ROCRSSI is based on the assumption that in a certain range of direction, with the increase of distance between a sender and a receiver, the signal strength at the receiver decreases monotonically. This assumption is usually true for

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