CUBOID-BASED WIRELESS SENSOR NETWORK LOCALIZATION ALGORITHM

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ABSTRACT

Localization is one of the key technologies in wireless sensor networks (WSNs), since it provides fundamental support for many location-aware protocols and applications. Constraints on cost and power consumption make it infeasible to equip each sensor node in the network with a global position system (GPS) unit, especially for large-scale WSNs. A promising method to localize unknown nodes is to use anchor nodes, which are equipped with GPS units among unknown nodes and broadcast their current locations to help nearby unknown nodes with localization. In this paper we can proposed a novel algorithm of cuboid localization with the help of central point precision method. Simulation shows that the results are far better then existing cuboid methods and gain accuracy of up to 83% with a localization error of 1.6m and standard deviation of 2.7.

KEYWORDS

Network Protocols, Wireless Network, Mobile Network, Virus, Localization

1. INTRODUCTION

Wireless Sensor Network (WSN) is a network of multi-hop self-organizing wireless communication system. WSN consist of a set of physically small and cheap micro-sensor nodes deployed in a given monitoring area (region), namely, in two-dimensional (2D) or three-dimensional (3D) environments, to fulfill tasks such as surveillance, biological detection, home care, object tracking, etc., [1-4]. The monitoring information is sent to sink nodes via multi-hop communication [5]. The sink collects the sensing data from the sensor nodes and then processes this information as required by the specific applications [6,7].

In WSNs, determining unknown nodes' locations is a critical task since it provides fundamental support for many location-aware protocols and applications, such as location-based routing protocols, where the location information is critical for sensor nodes to make optimal routing decisions [8,9]. The problem of localization is the process of finding location information of the sensor nodes in a given coordinate system. To localize a WSN in the global coordinate system, some special nodes should be aware of their positions in advance from Global Position System (GPS), which are called anchors (beacons). Other nodes, which are usually called unknown nodes, calculate their positions by using special localization algorithms [10-12]. The performance of the WSNs localization algorithm depends on different network parameters such as the number of anchors, the communication range, the network topology, the density of nodes and so on. Sensor nodes localization usually consists of two steps: (i) distance and angle measurements between neighboring nodes, and (ii) geometric calculation based on measured distances and angles.

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Based on the distance and angle measurement techniques used, localization algorithms can be classified into range-based localization algorithms and range-free localization algorithms.

2. RELATED WORK

Many techniques have been proposed to determine the locations of the nodes in WSNs. A general overview of state-of-the-art localization methods is available in [13]. In this section, existing works under both the range-based and range free context are reviewed.

2.1. Range - Based Methods

The measuring technologies in the range-based category consist of the received signal strength indicator (RSSI) method, the time of arrival (TOA) method, the time difference of arrival (TDOA) method and the angle of arrival (AOA) method.

The RSSI method applies a known mathematical model describing the path loss attenuation with distance [14]. The receiving node measures the strength of received radio frequency signal, which is compared with the original transmit signal power to obtain the propagation loss of the communication path. This propagation loss can be converted to the distance between two nodes using the empirical model and theoretical formulas. As a result, the locations of the nodes can be determined using classic geometric relationships. However, any obstacles between nodes lead to decrease the RSSI, which considered as error leads to longer distance. Moreover, multipath in signal reception leads to error in distance measurement by constructive or distractive interference. In the TOA method, the propagation time of radio frequency signal can be measured from the transmitting node to the receiving node.

2.2. Range - Free Method

Range-free methods are proposed as a cost-effective alternative to range-based methods. They depend on the connectivity between nodes and anchors. Moreover, range-free methods avoid costly hardware by exploiting inter-node communication and the sensing range of the node to estimate node locations. On the other hand, range free methods accept more localization error as a tradeoff.

In the centroid localization algorithm (CLA) [15], all nodes calculate their locations as the centroid of all received anchor’s locations. However, the inherent bias of the CLA is not considered. In recent years, weighted methods are proposed to improve the centroid algorithm. The DV-Hop algorithm can find the locations of the nodes using fewer number of anchors [16-18]. Instead of one hop broadcast, the anchors are flooded in the entire network maintaining the hop count and distances from anchors in each hop.

3. PRELIMINARIES & MOTIVATION

3.1. System Model

For the cuboid generation centre of gravity plays an important role having equal effect with neighbouring beacon nodes. This algorithm allows to all unknown nodes having one beacon nodes and a triangulation formation. For lower localization error all the nodes are deployed randomly and uniformly. For uniform distribution of beacons consider an array of beacons node broadcasting signals to all unknown nodes with its location and id.

$$B_i = (B_i + B_{i+1} + B_{i+2})/3 \quad (1)$$

The localization error is quite high so we need to reform some model which can satisfied the following relation.

$$E[eul]_i = \sqrt{(B_{i-1} - B_i)^2} \quad (2)$$

$$E[disp] = (B_{i-1} - B_i)^2 \quad (3)$$

3.2. Motivation

The existing localization methods suffers high localization error, energy consumption and computation resources. The range based methods show more accuracy compared to range free methods. In contrast, the range based methods have the following problem:

1) *Received signal strength indicator (RSSI):* the RSSI suffers from multi path problem, which creates error in distance measurement by constructive interference (i.e. shorter distance measured) or distractive interference (i.e. longer distance measured). Moreover, RSSI suffers from attenuating obstacles, which gives wrong distance estimation and may leads to miss angle calculation if no other method is used for angle measurement. The RSSI models are also considered for image, VANET and RFID tag localization [19-22]
2) *Time of arrival (TOA):* the TOA suffers from miss synchronization among WSN nodes. In contrast, to improve the synchronization each node must be equipped with advanced clock generator that is resource consumption and leads to higher cost.
3) *Time difference of arrival (TDOA):* the TDOA shows promising idea but lack implementation because it needs two different types of signals. Each signal mush has its own receiver, which increase the node size, cost and energy consumption. If TDOA can be used with the same signal, it will be much better and cheaper.
4) *Angle of arrival (AOA):* the AOA is the best way to measure the angles between nodes. However, attaching an antenna array with each node will increase the node size, cost and energy consumption. Moreover, to transmit a packet per each neighbouring node gives high energy consumption and delay.

In order to improve the localization performance by minimizing the localization error and decrease the nodes energy consumption, cost and size, this paper targets shifting the complexity of the localization system to anchors. This make the sensor nodes cheaper, more energy saving and has low required resources. In other words, we aim to benefit from the anchors advanced capabilities and power to achieve higher accuracy (i.e. less than 0.2 m) and cheaper nodes [23-25].

4. ALGORITHM DESIGN

The entire localization algorithm will be as follows.

1. The beacon nodes broadcast its id and location to all the nodes in a network to be localized.
2. The beacon nodes further select three more nodes to form the triangulation. All the triangles are not overlapped
3. The distance from nodes to each beacon is computed using RSSI.
4. The RSSI data set is recorded in a table with further used in error computation.

5. Compute the spherical area to calculate the network boundary. If there is no node in a boundary, its already localized or node failure.

The algorithm of the entire process is explained here.

Input: beacon-centroid pair $[B, CG_i]$, random approximation point $[E_i]$

If $\boldsymbol{E[disp]} > 0$

$B_i =$ upper bounding
CG_i = lower bounding

Else

B_i = lower bound point (L_P)
C_{Gi} = upper bound point (U_P)

2. Computation of network area (a) $= \frac{CG_{i\,Eui}}{2}$
3. Consider a 3d region
3. onward 3D interplanetary $SS_F = LE_P$ + CE
   contrary 3D interplanetary $SS_R = EU_P$ - CE
4. **Repeat**
5. Euclidian distance $[CE_i]$ and $[SS_{jF}]$
   Compute Euclidian distance amid $[CE_i]$ and $[SS_{jF}]$
6. Is $DR_{j\,Eui}$ is minimum
7. **Until** $DF_{j\,Eui}$ and $DR_{j\,Eui}$ is minimum
8. Calculate S_{jF} S_{jR} from S_F and S_R at $DF_{j\,Eui}$ and $DR_{j\,Eui}$
9. The system self-calibration and arrival time estimation.
9. Predictable opinion: $PC_{iE} = EP_{fF} * ES_{jF} + PES_{fR} * ES_{jR}$
10. distance computation RSSI
11. RSSI in a table form.
12. Centroid formula for distance

Output: distance: localization error.

5. SIMULATION

As the algorithm is dynamic nature, we choose the area of (1000 x1000 x 1000)m in a 3d space. Initially we choose 40 beacons and 50 unknown nodes to compute the localization error. The localization error also checks by increasing the number of beacons nodes. We found that the error is continuously decreasing by increasing the number of nodes. The error plot is shown in fig 1.

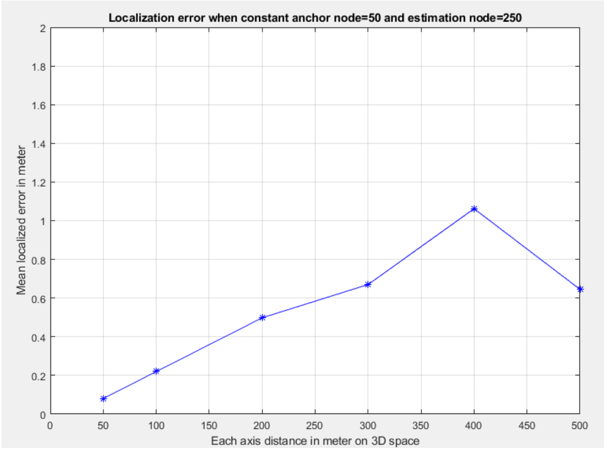

Figure 1. Localization error along with each distance in meter

6. Conclusion

Localization is misery from accuracy and error distance. In this proposed method we proposed a new localization algorithm which is free from network coverage, and noisy data element. The density of beacon nodes also plays an important role in decreasing the localization error. Future works encompasses study of accuracy in noisy environment, uniform random distribution analysis and reduction of localization error. In particular, we also consider lower bounding and upper bounding in localization error.

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