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A Survey - Iterative Localization of Wireless Sensor Networks

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ABSTRACT: In wireless networks, the localization is considered to be the major part. The localization needs more knowledge to implement and execute on wireless sensor networks. The localization is based on the communication between the nodes. Due to this reason, robustness and throughput errors occur in the wireless sensor networks. Some existing methods and research works related to localization states that, the communication problem occurs due to radio range. In this paper, the iterative localization of sensor network is implemented using Multi-hop Adaptive and Iterative Localization (MAIL) algorithm. The existing methods and works states the localization problem is due to the changes in the signal strength and in the received signal's angle. The iterative localization is proposed to overcome these issues. In this proposed method, a anchor based network with different nodes is preferred. The directional antenna helps in the communication of position between the anchor node and the neighboring nodes. The neighboring node decides the location using the angle of arrival based on the signal strength of the received signal and the anchor node's location. The information is shared to all the nodes and the location is also decided based upon the received signal strength. The iterations are looped to overcome the existing issues. The proposed method makes to understand the efficiency and accuracy rate is high when compared with existing methods. The proposed method helps to overcome the error of estimation, localization issues, computational cost and implementation time.

KEYWORDS: Wireless Sensor Networks (WSNs), Localization, Received Signal Strength (RSS), Angle of Arrival (AOA).

I. INTRODUCTION

A wireless network is any type of computer network that uses wireless data connections for connecting network nodes. Wireless networking is a method by which homes, telecommunications networks and enterprise (business) installations avoid the costly process of introducing cables into a building, or as a connection between various equipment locations. Wireless telecommunications networks are generally implemented and administered using radio communication. This implementation takes place at the physical level (layer) of the OSI model network structure.

Wireless sensor networks (WSNs) have been proposed for various applications including search and rescue, disaster relief, target tracking, and smart environments, accurate localization results help further sensor deployment. There is a growing demand for supporting location-based services to mobile nodes. Node localization has been an important area that attracted significant research interest.

II. TYPES OF WIRELESS NETWORKS

Wireless PAN

Wireless personal area networks (WPANs) interconnect devices within a relatively small area, that is generally within a person's reach.[3] For example, both Bluetooth radio and invisible infrared light provides a WPAN for interconnecting a headset to a laptop. ZigBee also supports WPAN applications.[4] Wi-Fi PANs are becoming commonplace (2010) as

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equipment designers start to integrate Wi-Fi into a variety of consumer electronic devices. Intel "My WiFi" and Windows 7 "virtual Wi-Fi" capabilities have made Wi-Fi PANs simpler and easier to set up and configure.[5]

Wireless LAN

A wireless local area network (WLAN) links two or more devices over a short distance using a wireless distribution method, usually providing a connection through an access point for Internet access. The use of spread-spectrum or OFDM technologies may allow users to move around within a local coverage area, and still remain connected to the network.

Products using the IEEE 802.11 WLAN standards are marketed under the Wi-Fi brand name. Fixed wireless technology implements point-to-point links between computers or networks at two distant locations, often using dedicated microwave or modulated laser light beams over line of sight paths. It is often used in cities to connect networks in two or more buildings without installing a wired link.

Wireless mesh network

A wireless mesh network is a wireless network made up of radio nodes organized in a mesh topology. Each node forwards messages on behalf of the other nodes. Mesh networks can "self heal", automatically re-routing around a node that has lost power.

Wireless MAN

Wireless metropolitan area networks are a type of wireless network that connects several wireless LANs. WiMAX is a type of Wireless MAN and is described by the IEEE 802.16 standard.

Wireless WAN

Wireless wide area networks are wireless networks that typically cover large areas, such as between neighboring towns and cities, or city and suburb. These networks can be used to connect branch offices of business or as a public internet access system. The wireless connections between access points are usually point to point microwave links using parabolic dishes on the 2.4 GHz band, rather than omnidirectional antennas used with smaller networks. A typical system contains base station gateways, access points and wireless bridging relays. Other configurations are mesh systems where each access point acts as a relay also. When combined with renewable energy systems such as photovoltaic solar panels or wind systems they can be stand alone systems.

Cellular network

A cellular network or mobile network is a radio network distributed over land areas called cells, each served by at least one fixed-location transceiver, known as a cell site or base station. In a cellular network, each cell characteristically uses a different set of radio frequencies from all their immediate neighbouring cells to avoid any interference.

When joined together these cells provide radio coverage over a wide geographic area. This enables a large number of portable transceivers (e.g., mobile phones, pagers, etc.) to communicate with each other and with fixed transceivers and telephones anywhere in the network, via base stations, even if some of the transceivers are moving through more than one cell during transmission.

Although originally intended for cell phones, with the development of smartphones, cellular telephone networks routinely carry data in addition to telephone conversations:

Global System for Mobile Communications (GSM): The GSM network is divided into three major systems: the switching system, the base station system, and the operation and support system. The cell phone connects to the base system station which then connects to the operation and support station; it then connects to the switching station where the call is transferred to where it needs to go. GSM is the most common standard and is used for a majority of cell phones.

Personal Communications Service (PCS): PCS is a radio band that can be used by mobile phones in North America and South Asia. Sprint happened to be the first service to set up a PCS.

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D-AMPS: Digital Advanced Mobile Phone Service, an upgraded version of AMPS, is being phased out due to advancement in technology. The newer GSM networks are replacing the older system.

Localization in Wireless Sensor Networks (WSNs) refers to determining the geographical coordinates of each node. Applications like target tracking [1], habitat monitoring etc require information about physical location of every node in the network. Localization also helps in data packet routing [2] and collaborative information and signal processing [3]. More over once location of a node in network is known, the coordinates that eventually will save the size of data packet to be sent by it can simply replace its node ID.

Single-Target/Source Localization in Wireless Sensor Network

The source localization methods have a wide range of possible applications. The outdoor application includes vehicle or aircraft localization. In an indoor environment, this method could track the human speakers. In underwater environment, it can be used to locate the large sea animals and ships. There are several ways to estimate the source location: energy-based, angle of arrival (AOA), time difference of arrival (TDOA). As an inexpensive approach, energy-based method is an attractive method because it requires low hardware configuration. In this survey, we focus on the energy-based source localization.

Single-Target/Source Localization in Wireless Binary Sensor Network

Most of the source localization methods are focused on the measured signal strength; that is, the fusion center knows the measurements of the nodes. In order to obtain the measurements, the node needs the complex calculating process. The above methods require transmission of a large amount of data from sensors which may not be feasible under communication constraints. The binary sensors sense signals (infrared, acoustic, light, etc.) from their vicinity, and they only become active by transmitting a signal if the strength of the sensed signal is above a certain threshold. The binary sensor only makes a binary decision (detection or nondetection) regarding the measurement, and consequently, only its ID needs to be sent to the fusion center when it detects the target, otherwise it remains silent. So the binary sensor is a low-power and bandwidth-efficient solution for wireless sensor network.

Node Self-Localization

Range-Based Localization

The classic methods to estimate the indoor location are time of arrival (TOA), time difference of arrival (TDOA), angle of arrival (AOA), and received signal strength (RSS). TOA method measures travel times of signals between nodes. TDOA method locates by measuring the signals' arrival time difference between anchor nodes and unknown node. It is able to achieve high ranging accuracy, but requires extra hardware and consumes more energy. As an inexpensive approach, RSS has established the mathematical model on the basis of path loss attenuation with distance and it requires relatively low configuration and energy.

Range-Free Localization

Hop-Count-Based Localization

As range-free positioning system, DV-Hop is the typical representation. It does not need to measure the absolute distance between the beacon node and unknown node. It uses the average hop distance to approximate the actual distances and reduces the hardware requirements. It is easy to implement and applicable to large network. But the positioning error is also correspondingly increased.

In wireless sensor networks, an important research problem is to use a few anchor nodes with known locations to derive the locations of other nodes deployed in the sensor field. A category of solutions for this problem is the iterative localization, which sequentially merges the elements in a network to finally locate them. Here, a network element is different from its definition in iterative trilateration. It can be either an individual node or a group of nodes. For this approach, we identify a new problem called inflexible body merging, whose objective is to align two small network elements and generate a larger element. It is more generalized than the traditional tools of trilateration and patch stitching and can replace them as a new merging primitive. The research paper is sectioned as follows. The

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section II presents the review related to the proposed work, section III is to explain the methodologies of proposed work, section IV detailed the results of proposed work and section V concludes the entire paper.

III. LITERATURE SURVEY

B. Xiao, L. Chen, Q. Xiao, and M. Li, Reliable anchor-based sensor localization in irregular areas

The location application is difficult for the network and data operation and also it needs more effort to connect each sensor with the positioning device. The existing methods require high density network. Localization is difficult to handle in sparse networks and it is dense in communication. One of the first multihop localization algorithms are the ad hoc positioning system (APS) proposed. In this paper, a novel scheme called reliable anchor-based localization (RAL) is proposed, which can greatly reduce the localization error due to the irregular deployment areas. The theoretical analysis of the minimum hop length is analyzed first for uniformly distributed networks and then show its close approximation to empirical results, which can assist in the construction of a reliable minimal hop-length table offline. Using this table, it is easy to conclude whether a path is severely detoured and compute a more accurate average hop length as the basis for distance estimation. The advantage of this paper is that filters the unreliable anchors effectively and the localization accuracy is improved. The disadvantage is that it requires the sensors to be densely distributed in convex area and the corruption in multihop based algorithm.

L. Dimitrios, L. Quentin, and S. Andreas, An empirical characterization of radio signal strength variability in 3-D IEEE 802.15.4 networks using monopole antennas

The radio connectivity and the attenuation of radio signal with distance is implemented in many devices. The most commonly one in the low-power radios is Radio signal strength indicator (RSSI). To investigate RSSI and its factors, and to get a better understanding of the asymmetries that arise in 3-D schemarios, a detailed characterization of signal strength behaviors in an IEEE 802.15.4 sensor network with monopole antennas is presented. A collection of a large number of measurements from a 40-node tested, both in an indoor and an open-field environment. This characterization examines a new radio technology with less powerful radio transmissions. Though there is no existence of multipath effects, the relative antenna orientation between receiver-transmitter is considered to be a main factor. This suggests that many schemes using radio signal strength on similar radios should carefully consider these factors before going to actual deployments. The merits in the work are that it has high signal strength variability component and computational complexity is less. And the demerits are that the packets are not received accurately and in low power condition, the RSSI is difficult to set to the signal propagation model.

H. Lim and H. J. C. , Localization for anisotropic sensor networks

Driven by advances in MEMS micro-sensors, wireless networking, and embedded processing, ad-hoc networks of de- vices and sensors with (limited) sensing and wireless communication capabilities are becoming increasingly available for commercial and military applications such as environmental monitoring (e.g., traffic, habitat, security), industrial sensing and diagnostics (e.g., factory, appliances), critical infrastructure protection (e.g., power grids, water distribution, waste disposal), and situational awareness for battlefield applications. Localization for wireless sensor networks has been intensively studied in recent years, A simple approach of having all the sensor nodes equipped with a global positioning system (GPS) does not suffice because of the size, cost, and power consumption constraints of sensor nodes. Instead, most localization methods determine the positions of sensor nodes under the assumption that a small portion of sensor nodes, called beacon nodes, are aware of their positions by means of manual configuration or GPS . In these methods, each sensor node estimates (based either ranging techniques or proximity measurements) its distances to beacon nodes, and calculates its position by triangulation flateration techniques. Refinement can be made to iteratively improve the accuracy of these localization methods. In this paper, we present a new technique to analyze the relationship between the geographic distance and the proximity between sensor nodes in anisotropic networks. Conceptually localization can be considered as an embedding problem that maps the set of objects into an embedding space. In Lipschitz embedding, a coordinate

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space is defined such that each axis corresponds to a reference set of objects and the coordinate values of an object o are the distances from o to the reference objects. Based on this concept, each sensor node has two coordinates in Lipschitz embedding spaces that correspond, respectively, to the proximity measure and the Euclidean distance between itself and beacon nodes. We derive an optimal linear transformation that projects one embedding space (that is built upon proximity measures) into the geographic distance space by using the singular value decomposition (SVD) technique. The advantages of this paper are that the characterization is accurate, the level of computational complexity is low and the protocol operations are simpler. The disadvantage of the paper is that is that the difficulty in extraction of geographic information and the power control in an excessive way.

IV. MAIL ALGORITHM

The proposed system is implemented with a base anchor node and different nodes are preferred. The anchor node holds compass and the remaining nodes consists of fixed range of transmission power and limited communication. The remaining preferred nodes have transmitting and receiving data packets capability in both full and half duplex modes. Once the process is started, the anchor nodes act as the transmitter and the remaining nodes as receiver. The data packet which is transmitted includes id, coordinates and angle of transmission information. It transfers in all the directions based on the beam's rotation. The implementation process P-1 is detailed below and initially the hop value is assumed as zero. The data packet which is transmitted is presented below and it is same for all the preferred nodes.

Implementation of Anchor Node (P-1)

- 1) The data packet is transmitted to all the nodes in all the directions and this step is termed as "Transmission Mode".
- 2) Once transmitted, the anchor mode is changed to the receiving state to receive the beamform in the received directive. This step is referred as "Listen Mode"
- 3) The step 1 is processed iteratively as proposed.

The data packet representation is as below.

Node ID	Hop Count	Co-ordinates		Angle of Transmission
		x_1, x_2	y_1, y_2	

The hop count for all the nodes is computed as N with respect to distance from the base anchor node based on the method proposed. The determination of location is started from the nodes in first hop. The proposed MAIL algorithm is implemented and it is evaluated to all the preferred nodes. The study reveals that the addressed issue seems to reduce when the iteration is stepping. The MAIL algorithm implements the second process (P-2) when localization is processed from one node to next node.

A. First Hop Node - Localization

The node j in the first position determines its first hop and implements the second process. The anchor node transmits the data packet to the node which is in first position. The node calculates its hop count, angle of transmission. The hop value is computed using the id and the hop point of the node. The AoA approach helps in the calculation of angle of transmission. The co-ordinates x and y helps in the computation of distance (d_{ij1}, d_{ij2}). Angle field and AoA technique combine to give $(\theta_{ij1}, \theta_{ij2})$. The co-ordinates x and j values are equated as below.

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$$X_{j1} = x_i * \begin{bmatrix} d_{ij1} \times \cos(\theta_{ij1}) \\ d_{ij1} \times \cos(\theta_{ij2}) \\ d_{ij2} \times \cos(\theta_{ij1}) \\ d_{ij2} \times \cos(\theta_{ij2}) \end{bmatrix} \dots\dots\dots(1)$$

$$y_{j1} = y_i * \begin{bmatrix} d_{ij1} \times \sin(\theta_{ij1}) \\ d_{ij1} \times \sin(\theta_{ij2}) \\ d_{ij2} \times \sin(\theta_{ij1}) \\ d_{ij2} \times \sin(\theta_{ij2}) \end{bmatrix} \dots\dots\dots(2)$$

The nodes j and k is assumed as first hop. The location for nodes are computed as $U_{j1} = [x_{j1}, y_{j1}]$ and $U_{k1} = [x_{k1}, y_{k1}]$. The location is shared between k and j based on the data packets. Node k's x, y coordinates are non-singular therefore region of node j with respect to it will be large. Therefore, node j determines its uncertainty region with respect to the farthest vertex of node k as U_{ki} . The uncertainty region of node j with respect to all possible points inside U_{ki} is computed as the minkowski sum.

$$U_{j2} = U_{ki} (+) U_{k1} \dots\dots\dots(3)$$

This uncertainty region is intersected with U_{j1} and becomes U_{j1} . Same code is run by all nodes in first hop. After running its fixed number of iterations in *n*th hop nodes, (*n+1*)th hop nodes determine their hop count and location similarly till all *N* hop nodes are localized. The termination condition check if all vertices of U_{j1} are equal to a singular point then execution must stop, as further reduction in size of region is not possible. The further execution of algorithm will increase cost of communication without any advantage in localization error.

Implementation of Algorithm for all Nodes (P-2)

- 1) Iterations, $i= 1$ to *N*
- 2) Hop count = $n+1$ on iteration
- 3) AoA is computed on own when hop count = 1 else based on the above equation (3).
- 4) Intersection is handled when it is old region
- 5) Data packet is transmitted by adjusting the beam
- 6) Process is terminated based on the above d stated last eqn (2). If it meets the condition, the process is sent to step 7 else it is sent back to the 3 step.
- 7) End implementation process.

Termination condition for pseudo code (P-2)

$$\sum_{k=1}^k (x_k - x_{j'})^2 + (y_k - y_{j'})^2 \dots\dots\dots(4)$$

where, (x_k, y_k) is the *k*th vertex of an L-vertex uncertainty region of *j*th node and $(x_{j'}, y_{j'})$ is the centroid of the uncertainty region.

B. Localization by subsequent hop nodes:

The fixed number of iterations of same code (c-2) is run by all nodes in subsequent hops to determine and update their feasibility regions.

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V. SIMULATION AND RESULTS

The simulations for proposed algorithm are done in Matlab. The simulation setup consists of 100 unknown nodes deployed randomly in a field of 100m x 100 m field. Fig. 1 shows 100 nodes divided into hops according to the distance from anchor node at (xi,yi). The red, green, blue and orange dots indicate nodes at 1st, 2nd, 3rd and 4th hop from anchor respectively. The anchor node is situated at (50, 50) and is indicated by red. Every sensor node can communicate with other sensors if distance between them is smaller than sensor range. Transmission range for each node is fixed at 18 m. For all possibly communicable nodes, the algorithm for localization comprising implementation process P-1 and P-2. The maximum number of iterations run for each node is only 5, practically the number of iteration may be < 5 for some nodes because of the termination condition given in (c). The localization error for each hop nodes is determined for different values of variance in angle $\sigma_{angle}(ij)$.

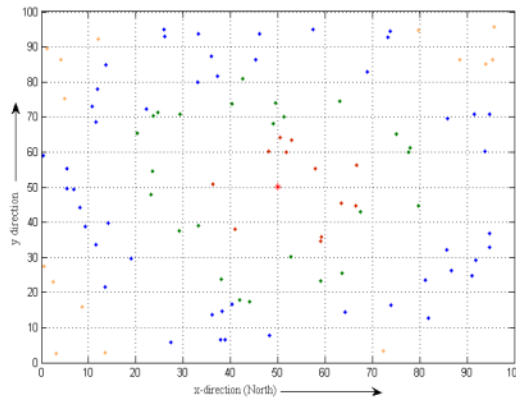


Figure 1 - Node Assumption in 100 * 100 m

Fig. shows the uncertainty locations after 1st and 5th iteration for all 100 nodes in 4 hops after running 5 iterations of MAIL with $\epsilon_0=0.5$ m and $\sigma_{angle}(ij)=5$ degree. The locations indicated with red, green, blue and orange after 1st iteration of algorithm for 1st, 2nd, 3rd and 4th hop nodes respectively. Reduced locations for each node after 5th iteration are shown as black patches.

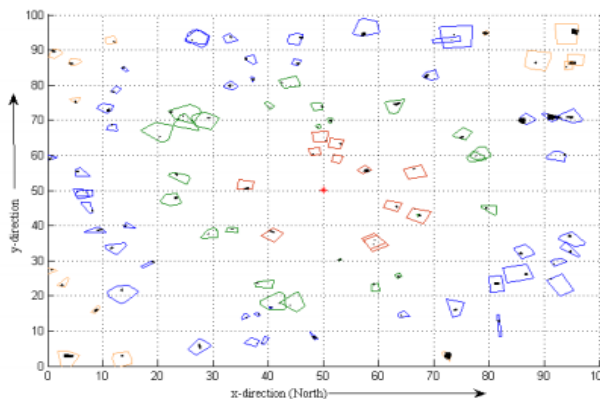


Figure 2 – Location Determination after Iteration

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Fig. 3 shows percentage of mean area reduction per iteration for all nodes in each hop from a reference area. The reference area is of the uncertainty locations formed for a node at first hop from anchor. Coordinates (x_i, y_j) , of an unknown node are approximated by taking centroid of the remaining region. The estimated locations and actual coordinates are almost overlapping with each other.

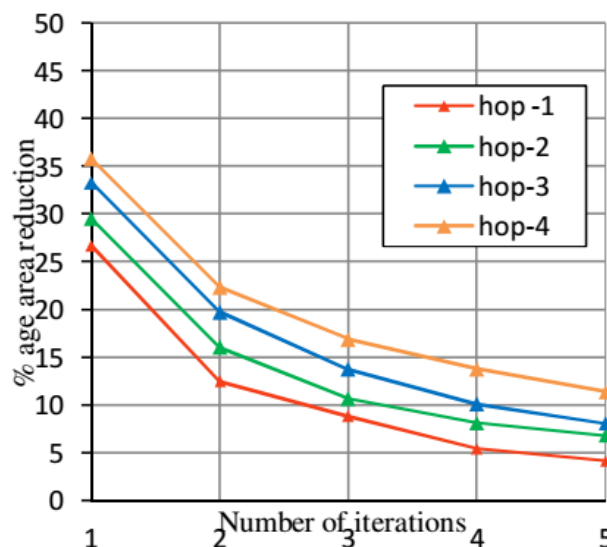


Figure 3 – Remaining Locations after Iteration (in %)

VI. CONCLUSION AND FUTURE WORK

The reason to propose this paper is to study about the localization of wireless networks and the error in estimating the method and also the iterations in the localization. The implementation of this method does not require any special software or hardware and computational time is also less. It can be also implemented without beacon nodes. Due to this reason, the cost of implementation is low. The proposed work using MAIL algorithm is the accuracy rate is high either large or small number of nodes. In future, it can be implemented with some other methods and the comparative study can be presented.

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