Localization in WSN based on Area of field and mobility : A Survey

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DOI: http://dx.doi.org/10.31642/JoKMC/2018/100109

Received Dec. 12, 2022. Accepted for publication Mar. 21, 2023

Abstract— *Localization in Wireless Sensor Networks (WSNs) is process to determine the locations of sensors connected within a network. Several applications need to determine the location of sensor nodes in the network to help increasing network performance. Some applications, such as item tracking, military operations, routing protocols, robotics, and inventory management, are made feasible by sensor network's ability to accurately locate the sensor nodes. For each of these applications, different criteria for position estimation. These are speed, accuracy, and reliability. In this paper we going to classify the localization algorithms with a new perspective based on three criteria (area of fields, cooperation between nodes and node's mobility). Following along this paper may give's an idea to the researchers to develop efficient algorithms to localize nodes with accuracy adapting to different techniques with respect to the geographic area and anchor type to be designed.*

Keywords— WSNs, localization, sensor nodes, RSSI, mobility, static

I. Introduction

A wireless sensor network is made up of small sensor nodes that may wirelessly interact with each other to monitor area of interest [1] . Some of data gathered is dependent on the precise position of sensor nodes. Localization is one of the fundamental and key technologies of WSNs [2]. Many additional network functions may be enhanced based on our understanding of the information that comes from sensed data and location, giving that the information of a location plays a key role in making sensed data spatially relevant. The additional network functions such as network routing, topology control, congestion management, coverage, border detection, clustering. Will be improved with the use of sensed data and position information [3]. However, without the position information, the sensor data is often of little value in many applications. This is because, the lack of location information can result in an incorrect interpretation of data, As a result, the researchs that are interest in WSN localization has recently increased significantly [4] **.** According to some of authors works in this field [1-5]

Each sensor node has the following primary parts: computing power, memory, an RF transceiver, a power supply [1] . In several sectors, WSNs are commonly utilized to handle sensitive data. Applications for WSNs may be found in the military, industrial, domestic, medical, maritime, and other domains, particularly in monitoring, early warning, rescue, and other emergency circumstances related to natural catastrophes. For instance, a smart dust network allows suspended nodes in the air to monitor the atmosphere's quality by detecting pressure, temperature, and other data from various places [5] . Users can use the sensor nodes in bird nests to do more study on the living behaviors of birds [6] . In this paper we proposed classification techniques based on geographical area, cooperate between nodes and Mobility. We organized the rest of our paper as follow. In Section II, we present prior researches related to this work. Farther more in Section III we will describe the localization process and Section IV provides a description of the different positioning strategies for estimating network node positions. Lastly Section V will provide a classification of localization techniques in WSNs. Section VI description conclusion.

II. RELATED WORKS

several survey articles have been presented on the subject of localization systems. Each one depend to some of criteria classify localization techniques.

Faheem Zafari Proposed in [7] survey several indoor localization methods (AoA, ToF, RToF, RSSI, CSI, etc.) and technologies (WiFi, UWB, Visible Light, etc.) have been described in depth. Using measures including energy economy, accuracy, scalability, reception range, cost, latency, and availability, the report assessed various systems. The study also outlined a number of difficulties such as Security, Multipath Effects and Noise, elc. related to indoor localization and offered broad guidelines and solutions that can assist in resolving these difficulties.

Saeed, N et al Proposed in [8] . A thorough analysis of MDS and MDS-based localization strategies in 5G networks, cognitive radio networks, the Internet of Things (IoT), and WSNs is offered by the authors.

Paul A.K. and T.Sato, in [9] . Authors research into various measuring methods and approaches for range-based and range-free localization, with a focus on the latter. Discuss further localization-based software applications. Finally, a thorough analysis of the issues, including accuracy, cost, complexity, and scalability, is provided.

Klogo, G.S. and J.D.Gadze in [3] . Study examines the various methods put forth to handle the WSN's location data gathering. And assessed the effectiveness of various approaches based on their energy consumption, the expertise and labor hours required to use them, and their localization accuracy (error rate).

Han, G., et al proposed in [2] . Thorough examination of the sample localization algorithms and reclassify the localization techniques from a new angle based on the mobility state of landmarks and unknown nodes.

Liu, M., et al proposed in [10] , overview of numerous indoor localization systems generated from diverse methods that offers absolute and relative range-based localization. Relative range based localization uses FMCW, the Doppler effect and phase shift while absolute range based localization mostly uses ToF.

Ibrahim, D.S., A.F. Mahdi, and Q.M. Yas, proposed in [1] a survey about the latest research in WSN for the years 2018-2020 , that elaborates the weaknesses of the existing approaches which make them appropriate for energy efficient routing in WSN. Also present the key challenges that face WSNs technologies. Researchers can find gaps and weaknesses in the literature using this categorization.

Islam, T. and S.-H. Park proposed in [11] , overview of newly suggested localization techniques underwater acoustic and optical sensor networks, the techniques used by each algorithm are briefly explained along with benefits and drawbacks. Two classes—Centralized and Distributed—represent the majority of the surveyed algorithms. Based on considerations for mobility and those that do not.

In [12] Han, G., et al reviews the many approaches created to deal with dynamic fluctuations in an interior setting.

Alakhras, M., M. Oussalah, and M. Hussein proposed The advantages of fuzzy sets, fuzzy logic, and fuzzy inference systems in wireless locating issues are shown in the research [13]that examine and research numerous strategies and techniques relevant to fuzzy systems

Sharma, N. and V. Gupta, proposed in [14]by explains how several metaheuristic algorithms may be used to tackle localization problems in sensor networks. A few of the metaheuristic algorithms that are employed to solve the localization issue are the firework algorithm, cuckoo search, bat algorithm and genetic algorithm. The study provides an overview of the wireless sensor network localization problem, its applications and a metaheuristic algorithm-based solution. The factors to consider while localizing are also covered in the study. The experiments demonstrate that the application of metaheuristics to the problem of wireless sensor network localization maximizes the outcomes. In the table 1 below, described of related works.

TABLE (1) described of related works

#ref	Classification technique	Publication Year
[7]	evaluate different systems from the perspective of energy efficiency, availability, cost, reception range, latency, scalability and tracking accuracy.	2019
[8]	a comprehensive survey is presented for MDS and MDS-based localization techniques in WSNs, IoT, cognitive radio networks, and 5G networks.	2019
[9]	various measuring methods range-free localization	2017
[3]	explores the numerous methods put out to deal with the gathering of location data in WSN.	2013
[2]	categorize the localization methods based on the mobility status of landmarks and unknown node .	2013
[10]	a comprehensive survey for range-based acoustic indoor localization.	2020
[1]	Survey the latest research in WSN for the years 2018-2020	2020
[11]	Classification into Centralized and Distributed	2020
[12]	provides an analysis of the most effective MANAL algorithms,	2016
[13]	Fuzzy sets, fuzzy logic, and fuzzy inference systems.	2020
[14]	metaheuristic algorithms	2020
The proposed survey	area of the field ,the cooperation between the nodes ,and the type of anchor	2022

III. LOCALIZATION IN WSNS

A crucial need in wireless sensor networks is the determination of the geographic position of wireless sensor nodes, also known as sensor localization (WSNs). In the majority of WSN applications, the locations from which sensor observations acquired are necessary. Additionally, a lot of networking protocols, like geographic routing, sensor cooperation and tracking demand an understanding of the sensors position. The size and cost limitations of the hardware in the sensor nodes must be taken into consideration while designing sensor localization, much like all other procedures carried out in WSNs. Furthermore, due to obstructions from trees or other physical buildings as well as being outside the range of cellular base stations, wireless sensor nodes may be situated in an environment that make it impossible for them to receive wireless signals from satellites. Therefore, current methods of estimating geographic position, including using the Global Positioning System (GPS) or cellular location services, are too expensive in WSNs. As a result, there has been a lot of research done on the creation of inexpensive sensor localization techniques that satisfy application requirements while operating within the hardware limitations of WSNs [15] Calculating the destination location is the main goal of localization, Since system could be self-organize throughout the communication between localized and un-localized nodes, localization estimates the location of an unknown node. The sensor nodes position data is crucial for the [16] routing services. A sensor network localization algorithm [17] .

IV. LOCALIZATION APPROACHES IN WSNS

Sensor localization techniques have been the subject of substantial research that addresses a wide variety of criteria and limitations, including accuracy, technology, communication, computational, node dynamics, hardware availability and many more. These methods can be generally categorized as shown in Figure 1

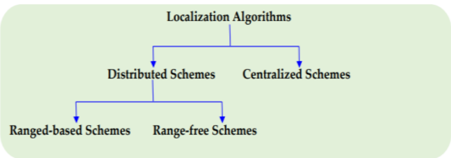

Fig. 1. Classification of wireless sensor localization schemes

1. CENTRALIZED TECHNIQUES

The central base station keeps track of the nodes and computes the distance between each one. The distance is sent back to the nodes after computation. Latency, bandwidth and energy utilization in this process are all caused by data transmission. Since centralized algorithms offer a broad perspective of the entire network, they are more accurate than dispersed networks. The result of this procedure is a lack of ability to access the data correctly. Due to their increased computational complexity and reliance on partial information, these methods are not appropriate for use in large-scale sensor networks.

2. DISTRIBUTED TECHNIQUES

The distance between neighbors and anchor nodes is calculated by the sensor nodes using a variety of measuring techniques in distributed localization systems. The sensor nodes interact with one another to determine their own position inside the network. The design of distributed algorithms is more challenging than the design of centralized algorithms. Distributed algorithms perform well in local network. Before a consistent answer is found, there are several iterations required. While centralized algorithms use a multi-hop mechanism to transmit information, distributed algorithms only require a single hop between nodes [18].Range-based localization systems and range-free localization methods are two categories for distributed localization technique [15].The range-based technique makes use of the estimated angle and distance to calculate location using geometrical concepts. The pattern matching and connectivity methodology are used by the range-free method to estimate position. In this case, hop counts are employed rather than straight distance calculations. Following the calculation of the hop counts, an average distance is utilized to estimate the distance between the nodes, and the computation of location is then done using geometrical principles [16].

V. CLASSIFICATION OF LOCALIZATION TECHNIQUES IN WSNS

In this section, will be classify the localization algorithms with a new perspective based on three criteria. These criteria are geographic area of fields, cooperation between nodes and anchor mobility

_ Mobility

due to the cost of (GPS) the number of anchors should be as less as possible, therefor several algorithms uses mobility in its localization. Therefore, moving anchor is used to reduce the number of anchor in the field of interest, as a result of reducing energy consumption and the cost of GPS. On the other hand, the number of statically anchors can be more than the mobile anchors. A greater number of anchor nodes may improve the location estimation's accuracy [16] . For more information see [18-21] .

_ Geographic Area

Localization algorithms are implemented on different areas depending on the sensor field and where they are deployed, some of them are implemented on small areas between [(10×10) ... (90×90)] square meters. Some of them are implemented on medium areas between [(100×100) ... (500×500)] square meters. Some of them are implemented on large areas between [(600×600) ... (3000×3000)] square meters.

_Cooperation

By classifying the methods below, we notice that some nodes cooperate with each other to locate unknown nodes. By making a connection is direct between the anchor nodes and the unknown nodes to locate unknown nodes.

Below is a summary of a classification of some of the methods used in the localization of wireless sensor networks based on the above criteria.

Chuku, N. and A. Nasipuri, presented a removal impact of such disproportionately inaccurate distance estimations using outlier detection techniques that is discussed for position estimation using RSSI. In order to successfully decrease localization errors in shadowed environments , three distinct localization strategies that employ outlier detection are offered in [15] , and by implemented this proposed on network region (100×100 m), (40×40 m), it can be implemented on an area of small or medium, with use a mobile robotic.

Sharma, A. and P.K. Singh, presented UNL, or unknown node localization, technique for determining the position of the sensor. The suggested approach is based on RSSI, hence additional hardware and data transfer between sensor nodes are not necessary. The studies to test the UNL technique's localization accuracy were carried out, and it was determined that the approach is straightforward since there is a minimal overhead in terms of computing and communication. For the precise estimate of unknown nodes, the proposed methodology is also compared to various current localization techniques. The experimental findings demonstrate the algorithm's efficacy and its capacity for more precisely locating the unknown nodes in a network in [16] . and implemented this proposed on network region (100×100 m), (200×200 m), (500×500m) it can be implemented on a medium area, with use four a static anchor and mobile nodes.

A hybrid RSS/AOA indoor localization technique based on error variance and measurement noise weighted least squares (ENWLS) is suggested by Ding, W., S. Chang, and J. Li. That High-precision indoor positioning is accomplished with this technique, which is based on three-dimensional wireless sensor networks, without adding to the complexity. We first approximate the linear weighted least square (WLS) error using the first-order Taylor approximation, then we use weighted least squares estimation to roughly estimate the target's location. Finally, estimate the linear WLS error variance and the measure the noise value on the sensor node to determine the weight matrix. The implement of The target and anchors are randomly deployed inside a box with an edge length B = 15 m for each Monte Carlo run (Mc) in [5] .

To increase the lifespan of these kinds of networks, in [19] . Rezaeipanah, A., H. Nazari, and M. Abdollahi a multi-level genetic-based clustering approach suggested. According to the radio range, the suggested multi-level clustering method splits the geographic region into three levels, with the nodes in each level being clustered individually. Technically speaking, Cluster Heads (CH) use more energy to transport data than other nodes. Therefore, the proposed approach tries to increase network lifespan by decreasing CHs. Finally, by changing the CHs in each routing cycle, a better energy consumption balance between the nodes is achieved. The results of the studies demonstrate the suggested algorithm's advantage over other comparable protocols in terms of and the network lifespan. and implemented this proposed on (100×100 m) network region, with the use of static anchor.

Three sections of Naguib A, the proposed multilateration, are utilized to represent the localization system that is being proposed .The first section states that every anchor node broadcasts its position to nearby nodes, who then calculate the distance to the anchor node. Each neighbor node (unknown in the second part, atomic multilateration) may determine its position using data from the first component. When an unknown node determines its position through estimation, it transforms into a reference node and broadcasts its location to its neighbors in order to determine where they are. The procedure used in the second phase is repeated in the third stage (iterative multilateration) until all or the majority of unknown nodes estimate their positions in[6]. and implemented this proposed on (200×200 m), (300×300m) network region, with the use of static anchor.

Tian, L. and Y. Fan proposed The SCAN ET algorithm's core notion is presented in [20]. First, all nodes in the monitoring regions are separated into two groups: nodes that have been located and nodes that still need to be found. The monitoring regions are then separated into a number of tiny zones, where the movable anchor node will select a different path—either a straight line or the sides of a triangle—depending on whether nodes need to be identified. If a node needs to be located around it, the movable anchor node will only move along a triangle and broadcast positional information at the triangle's three vertices. This reduces the mobile anchor node's movement distance and transmission energy usage. and implemented this proposed on (310×310 m) network region, with the use of mobile anchor.

Zhang, T, proposed (LLP) in large-scale and low-density WSNs, where accurate localization is typically rather challenging due to limited communication nodes and a significant range distant nodes error, this approach is particularly well suited for establishing the relative locations of sensor nodes. In this algorithm, the local geometry of the global structure is initially obtained by creating a local subspace for each node, and those subspaces are then aligned to give the internal global coordinates of all nodes. Within a specific communication range, the pair-wise distance between each node and its neighbors serves as the basis for this calculation. As a result of having information about the global structure and anchor nodes, we can use the least squares approach to determine the absolute coordinates of all unknown nodes in [21].

Luo, J. and L. Fan proposed TP-TSFLA features two stages in [22] Stage(1) reference nodes first transmitted beacons. The received beacons are used to pinpoint all sensor nodes that receive beacons. These recently located nodes serve as reference nodes to assist in the localization of the last un-localized node. All un-localized nodes step up their transmission strength to make beacon requests in stage (2). When a localized node gets a request, it reacts by sending a beacon. Until nodes are localized, the localization beacon request procedure that may continue. This algorithm uses a small number of mobile beacons to help obtain the location information without the use of any other anchor nodes, which may reduce communication overhead. However, this method may result in high communication overhead because a specific un-localized node that may receive unnecessary beacons from a large number of reference nodes.

Singh, P., et al proposed The position of the moving target nodes was to be determined using a new approach that relied on a single anchor node that had GPS and six virtual anchor nodes that encircled it in a circle in [23], [24].The nearest two virtual anchor nodes for the target node are used alongside the beacon node to estimate the target position. using artificial intelligence (AI) (CI) and implementation on small area.

In [18]. MDS (Multi-Dimensional Scaling) is a centralized technique with graph theory as its guiding concept, according to Sneha, V. and M. Nagarajan. The MDS's goal is to calculate the distance between locations in different dimensions. Machine learning and computational chemistry are two areas where MDS is used. MDS uses communication or distance information to locate a sensor. The MDS algorithm technique is used to identify the shortest paths for all node pairings. All sensor pairs connected to the two nodes' shortest paths are found when the distance between them along that path is calculated. This information is used to generate the distance matrix for MDS, where (i, j) denotes the distance between nodes i and j as determined by the distance matrix and the locations of each node's relative coordinates. In order to determine each node's relative coordinates, the distance (i, j) is applied to the distance matrix between nodes i and j after the distance matrix of the MDS has been constructed using this information. These relative coordinates are converted into absolute coordinates by aligning the relative anchor coordinates with the absolute coordinates. These location predictions are enhanced by using minimization of least squares. As a result of their increased computational complexity, they are inappropriate for use in massive sensor networks..

A methodology for localization and deployment was put out by Bhat, S.J. and S. KV [25], the deployment model for a fully linked network is developed using the findings of the Arithmetic Optimization Method (AOA), which is employed in the localization algorithm. This method has undergone several field tests. When the Average Localization Error (ALE) is within 5m, the method can localize nodes precisely and locate coverage gaps with an error rate of less than 0.27%, and implemented this proposed on network region (200×200 m), (250×250m) it can be implemented on an area of medium with the use of static anchor .

In the table 2 below, the various techniques for localizing the sensors in wireless sensor networks are contrasted in terms of the geographic scope of the application and whether or not the nodes cooperate when doing so.

TABLE (2) comparison between localization methods

#ref	Year	Technique and method	Anchor type	Cooperation between nodes	Direct AN with UN	Area	Description(uses, advantage)
[15]	2021	Maltilaeration , RSSI	Mobile	---	yes	suitable for large-scale and medium sensor network	suggests employing outlier identification techniques to mitigate the impact of such disproportionately inaccurate distance estimates while estimating location using RSSI.
[16]	2021	UNL, or unknown node localization	4 static	---	yes	suitable for large-scale sensor network	offer a method for locating the sensor nodes that cause the event. Major incidents like fires can happen in a variety of settings, including open spaces, businesses, homes, and forests.
[5]	2021	ENWLS based on hybrid RSSI/AOA measurements		---	yes	suitable for small-scale sensor network	gets the highest indoor location without making it more costly.
[19]	2020	multi-level clustering, GA		YES	---	suitable for large-scale sensor network	improve energy efficiency.
[6]	2020	Multilaeration	Static	Yes	---	suitable for large-scale sensor network	Iterative multilateration has a larger localization error and a larger percentage of localized sensor nodes than atomic multilateration, according to simulation data.
[20]	2018	SCAN_ET algorithm	Mobile	---	yes	Monitoring area size is 310x310 m ,the communication radius of nodes is 30m	beneficial for extending service life and improve energy efficiency.
[21]	2018	LLP local localization algorithm	Static	---	Yes	Suitable for big –area and low-density	The accuracy increases with decreasing the distance between nodes.
[22]	2017	TP-TSFLA(A Two-Phase Time Synchronization-Free Localization Algorithm)	Mobile	Yes	---	Suitable for large–area (1000,1500,2000)	TP-TSFLA reduce the localization error and that can achieve a relative localization ratio without time synchronization.
[23, 24]	2018 , 2017	Range based ,AOA,CI	Static	---	yes	Suitable for small scale area	For mobile targets or mobile anchors, the suggested methods may be used for centralized localization and range-free multi-hop localization.
[18]	2020	MDS MultiDimensional Scaling	Static	Yes	---	Not suitable for large-scale sensor network	Due to partial data and increased computing cost, these techniques are not suitable for big wsns.
[25]	2022	AOA arithmetic optimization algorithm	Static	Yes	---	Medium-scale	techniques to create a deployment strategy for a fully interconnected network.

VI. CONCLUSION

In this paper we present a survey of the recently proposed localization algorithms for sensor networks. The algorithms are classified based on geographical area, mobility anchor and cooperation with other nodes. Through the methods we discussed in this paper, we conclude that most of the ways in which there is cooperation between nodes use distributed algorithms. We also noticed the majority when the anchor node is moving, is a central cooperation, and when the anchor is stationary, it cooperates with other nodes to locate the other unknown nodes in the network.

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