IoT-WSN: Survey on Positioning Techniques

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Abstract

Recent advances in radio and embedded systems for completing the procedure of location estimation most of the time sensor networks are fully dependent on the distance measurements that is present between the sensor neighbourhood node. Techniques used for the localization can be categorized differently. Techniques used for the measurement of the distance between the wireless sensor nodes, dependent upon the physical means are divided into three broader categories namely Received signal strength (RSS), Angle of Arrival (AOA) and propagation base on time measurements. This paper discusses the most of the approached of WSN and IoT based positioning system.

Keywords

Wireless sensor network, RSSI, Mobile computing, IoT, Anchors, Beacons.

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 fulfil 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]. The sensor and anchors are deployed randomly in a network so that it can cover the full network in order to avoid the network coverage.

2. Taxonomy of WSN-IoT Based Positioning Techniques.

Positioning algorithms consist of range-based and range-free localization algorithms.

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.

A 3D localization technique is presented in [8-12] which utilizes the maximum likelihood estimation, sequence search and LMS along with iterative positioning methodology. A 3D network is considered in R3 with m anchors and n unknown nodes. Let $\theta = [\theta 1,...,\theta m,...,\theta m+n]T$ represents the original locations, where $\theta 1,...,\theta m$ and $\theta m+1,...,\theta m+n$are the locations of the unknown and anchors nodes, $\theta i = [xi,y\ i, zi]\ T$. Location of the anchor nodes are considered to be

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accurate with zero error. The estimated locations are presented by θ' where θi equals θi,i≤ m [13].

Noise can be calculated by the (1):

$$d_{ij} = r_{ij} + n_{ij} = \|\theta_i - \theta_j\| + n_{ij} \quad (1)$$

Where dij is the Euclidean distance between sensor nodes i and j and rij is the real distance between them. nij is the additive Gaussian noise of the distance estimation dij with mean μn and variance σ2n, and ‖.‖ denotes the 2-norm.

Each sensor node can employed MDEVM algorithm and MDESM algorithm for more complicated problems. In order to find their own (Xs,Ys,Zs) location.

This technique consolidates 3D Taylor algorithm, unitary framework pencil (UMP) algorithm, three- and multilateral algorithm for localization. UMP algorithm is extended in order to calculate the time of arrival and propagation distance between the two. Centro-Hermitian feature of a matrix and for the conversion of complicated matrix into simple matrix unitary transformation is utilized. This minimizes the processing time for real time implementation. For computing the position of node multilateral localization is utilized. Taylor algorithm is extent to 3D for solving nonlinear equations. In order to minimize the processing load and to enhance the resolution time UMP algorithm is enhanced to the use of UWB WSN.UMP base TOA localization algorithm is proposed in order to measure the distance between two hubs. The estimation results will be utilized as a part of 3D position calculation [14-17].

It is a 3D localization algorithm in which every sensor node measures the distance by utilizing the mobile beacon. Mobile beacons are aware of their own location by means of GPS and every beacon contains the current location of each mobile beacon. This algorithm presents a range base methodology, so that mobile beacon can utilize the UBW signal. It provides an efficient resolution for time and is quite useful for multipath execution. For high accuracy, it utilizes TOA systems. Finally, SDI is proposed for determining the 3D position of beacon node [18].

In [19-21], an enhanced 3D localization and a 3D limitation model are proposed to enhance positional precision and scope. The customary DV-Distance calculation is adjusted. The situating blunder brought on by combined separation is decreased through the revision parameter. The customary DV-Distance algorithm is adjusted. The position base error minimized by using correction parameters. The best situating unit which is based on DCP is chosen to decrease the positioning errors created by coplanar nodes.

The thought of elevating unknown nodes is proposed with a specific end goal of improving localization accuracy.

Quasi-Newton strategy is utilized to revise the position evaluated by quadrilateration. The simulation demonstrates that 3D-IDCP algorithm is more precise in localization. A neural network system-based approach is proposed in embraced in [22-25]. The Received Signal Strength Indicator (RSSI) estimations of anchor nodes are utilized. The number of anchor nodes and their mathematical configurations has effects on the location preciseness. Five distinctive training algorithms are analyzed in order to find the most accurate one. The multi-layer Perceptron (MLP) neural system model was prepared utilizing Matlab. So as to assess the execution of the proposed strategy continuously, the model acquired was then executed on the Arduino microcontroller. With four anchor nodes a normal 2D limitation mistake of 0.2953 m has been accomplished.

Authors have proposed the RSSI based technique for localization based on the Fuzzy logic. They named it as the fuzzy logic based multiliterate scheme for localization (FLMSL).The steps involved in the algorithm are as follow [26-29]:

Signal strength of the signal is calculated while the signal is sent from the signal node towards the sink node. This calculates the distance between the sensor node and anchor node. Distance is calculated by using Firris free transmission known as (2)

$$Pr = Pt\ Gt\ Gr\ \lambda 2 / (4\pi d)\ 2L \quad (1)$$

Pt represents the transmitted power while Pr presents the received power. Gr and Gt donates the gains of received and transmitted power by antenna. L is the loss donates the distance and λ indicates the Wavelength. Both distance and wavelength are measured in meters [30].

In [31], authors contemplated the effect of various types of spatial assorted qualities on the accuracy of localization in indoor situations while changing the shadowing impact. Authors have utilized the trilateration and multiliterate calculations, which are based on RSSI calculations, to appraise the objective position. Three framework models outlining the spatial differing qualities were considered: diversity based on the transmission (MISO), diversity based on received values (SIMO) and the diversity based on the received and transmission values both (MIMO).

In [32], the significant goal is to measure how accurate and precise is the RSSI model in a remote sensor system to assess the position of an agreeable target. In this work not, another complex location estimation strategy for Wireless Sensor Systems (WSN) has been created, yet the propose research actualize a straightforward confinement plan which is rather in light of a solid exploratory examination of Radio Signal Strength (RSS) as a separation estimation method in WSNs over the 433 MHz remote channel. Perceptions of this work is categorized in two general classifications, the principal ones depend on an adjustment-based examination and the second ones depend on a full - fledged plan for position estimation, the k – nearest neighbour match algorithm.

Paper proposed a hybrid algorithm named as Minimum AOA Error with Minimum RSSI Error (MAE with MRE) has been introduced. MAE with MRE can be utilized in wireless sensor networks which are more error prone [33].

Among numerous measurement techniques for localization, one importunate and pragmatic technique for signal calculation is the time of arrival of received signal within the areas of wireless sensors network. Without time stamp at the transmitter, in conventional practices, these received measurements of TOA are subtracted pairwise to extract time-difference of arrival (TDOA) statistics for source localization, which leads towards the 3-dB points loss in signal to noise ratio. Proposed algorithm has considered the disparate technique and applied the original received measurements without the pre-processing of subtraction. Two new techniques are applied that make use of semi definite programming (SDP) for localization of direct sources. Further the issues related to the inaccuracy of locations in sensors and errors related to the estimation of locations are also taken into consideration. Results exhibit some conceivable benefits of proposed algorithm of direct time of arrival data over the pre-processing of time difference data [34-35].

Localization preciseness can be acquired if the signals received are of good quality. In a practical implemented situation, clock base time drifting of devices in the wireless sensor systems have enormous impact on the localization exactness and ranging. In [25] authors utilize Time

Difference of Arrival (TDOA) technique to determine the location of a node. Specifically, the significance of time drifting in influencing the exactness of location accuracy is determined and algorithm is proposed to overcome time drifting while implementing the localization through the Time Difference of Arrival technique. Furthermore, the offset transmit time of the device is estimated so that this particular value can be compensated by making use of range base information. Along these lines, there is no necessity for the sensor nodes to be synchronized at first step [35-38].

Root mean square is calculated for finding the accuracy of the proposed algorithm and proposed model.

$$rmse = \frac{\sqrt{((x_i - x_{ei})(y_i - y_{ei}))}}{\text{n}} \quad (3)$$

Where, (xi, yi) are the original coordinates of the for the ith data nodes and (xei, yei) are the coordinates for the ith data 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 trade-off [39].

In [40], 3D range free strategy in an isotropic environment is proposed which uses the Bio inspired algorithm, Fire fly Algorithm (FA). Nodes are sent over the three-layer limits in which the upper layer contains the anchor nodes with known position that are haphazardly dispersed and the centre layer and the base layer contain the arbitrarily disseminated target nodes. Advanced edge weights between the anchor nodes and the objective node are utilized to find the area of the objective node. Fuzzy Logic System (FLS) is utilized to overcome the issue of nonlinearity between the Received Signal Strength (RSS) and distance. The consequences of proposed calculation are compared with the range free strategies [41].

$$d_i = \sqrt{\sum_{d_i=1}^{D} (x_{id} - x_{jd})^2}$$

Whereas xid and xjd is the position vector and I,j are the positions of fire flies. The position update is presented as:

$$x_i = x_i + \beta_o(1 + \gamma r_{ij})(x_j - x_i) + \alpha S(R - 0.5) \quad (4)$$

Where β is the brightness value and R is the set of random numbers which are uniformly distributed in the range of [0,1] while α is the random parameter and its value is also between 0 and 1.

Considering the incompleteness of localization data in wireless sensor networks, the sensor system observing area is distributed into small grids of networks. Targets and sensors are haphazardly dropped in this grid area. Information related to the target nodes is defined into sparse vectors and range free localization scheme based on the compressive sensing (MTLCS) is proposed. Just targets number detected by sensor nodes is required in the calculation. It doesn't rely upon additional equipment estimations [42,43].

WSNs provides numerous algorithms for indoor localization as well. The lifetime of localized node can be expanded by utilizing radios which are energy efficient and minimizing their dynamic time of activity [44]. Nonetheless, the most minimal effort and low-control radios do exclude Received Signal Strength Indicator (RSSI) based functionality which generally utilized RF-based estimations for localizations.

Range free techniques uses hop count information for measuring the shortest distance between two nodes and in addition also utilized scaling to assess the physical location of nodes. Scaling may introduce lot of errors either it is done in the domain of one anchor or topology based on local estimations. AS discussed in [45], there are lot of techniques which falls under the umbrella of range free algorithms, DV-hop (Distance Vector Hop) is also one of them. However, the customary DV-HOP has the accompanying drawbacks: the extensive overhead squanders the scalability and energy of the network and also increases the communication burden on each hop. To solve the above-mentioned issues, LHDV-HOP (DV-HOP based on limited Hops) is proposed in [46,47], in which a threshold for hop N in order to limit the range of flooding.

A novel approach in [48] is proposed based on the DV-hop. Proposed approach is based on the iterative computation which by decreasing the overall cost enhances the localization accuracy. Proposed algorithm has following steps: Each node broadcasts the hop count, its ID and its position to all other nodes. Each anchor node made calculation about the average hop size. Ci represent the average hop size of the anchor node i.

$$C = \frac{\sum c_i}{n} G \tag{5}$$

$$e = \frac{\sum_{i=1}^{n} c_i - C}{n} \tag{6}$$

Each anchor node makes use of C for estimating the distance from other anchor and find its position by using least square technique. Error will be calculated by:

$$error = \frac{\sum_{i=1}^{n} (x_{i,j} - X)2}{n} \tag{7}$$

Global average hop size nC= eCnC is corrected and error is calculated again nC is used for calculating global error. When the number of iterative cycles increased unknown nodes use nC for estimating distance from anchor node. Lastly position of unknown node is calculated by least square. Matlab based simulation is perform and compare the proposed technique with the DV-hop, corrected DV-hop, collinearity DV-hop. Results show that it provides greater localization accuracy as compare to the rest of techniques.

A method based on the Fermat point (FM) is presented in [49] known as FM-APIT-3D.In case of APIT-3D triangular pyramids are find in which unknown node is located. Then a special point known as Fermat point is located in this pyramid which lies at the minimum distance from the four corners of pyramid. This point is utilized to determine the optimized positional modelling. Pyramid is divided into four sections, and then it is made sure that piece of each triangle contains the unknown node, by technique of point in triangulation.

In [50] anchor nodes are utilized to implement the procedure of estimation of noise in the environment present within the sensing domain. These nodes will contrast the original distance with the distance measured by the RSSI technique. Relationship between the distance and RSSI is as follows:

RSSI = I0n log d + A (8)

where A is the RSSI value for a distance of 1 m and n is the path loss exponent with value n = 2.5 for indoor channels.

The distance between anchor nodes can be measured by following equation:

$$Da_{i,j} = \sqrt{(Xa_i - Xa_j)^2 + (Ya_i - Ya_j)^2} \quad (2)$$

Most past works accept isotropic systems where the shortest distance is estimated by the Euclidian distance. These methodologies can't acquire precise localization estimation in anisotropic systems where the shortest distance is not in linear relationship with the Euclidian distance. In the anisotropic network systems, the shortest way between two nodes might be rerouted and its length might be evaluated much larger than the relating Euclidean distance. Due to this phenomenon, it is vital to choose solid nodes which offer the unequivocally estimated distance-based calculation [51-52].

m is the anchor node and ʎ is density of anchor nodes.

$$p_M(m) = \frac{(\lambda\pi L_{4hop}^2)^m}{m!} e^{\lambda\pi L_{4hop}^2} \quad m = 0,1,2,\ldots \quad (3)$$

In [53] authors consider the sensor localization having the two problems: inaccurate position and noisy measurements in wireless sensor networks. To settle the non-traceable integrals in functions based on the likelihood, the authors in [63] utilizes the expectation maximization (EM) calculation to acquire the greatest probability (ML) estimation iteratively.

Proposed algorithm in [54] utilizes the shortest hop algorithm for upgrading of virtual anchor nodes. This calculation firstly picks out some special nodes from all the obscure ones to make sense of more exact positions of them, and at that point makes these ones as new virtual anchor nodes to help other nodes for in finding of their positions. The reproduction results delineate our calculation has enhanced the exactness of confinement incredibly. The researcher aim is to develop a topology control which ensures that networks remain connected and build an efficient energy so he considers a two dimensional randomly distributed network. The main goal is to use energy more efficiently and nodes enable that consume energy in a more uniform way. For this purpose, the researcher achieves this goal by defining weighted relaying regions and by defining eligibility metric. A topology control protocol is essential to set the number of links that can be active in the networks but in wireless networks physical elements of networks are directly connected with topology networks [55,56].

3. CONCLUSION

Localization is misery from accuracy and error distance. In this paper we have mainly discuss the most important and famous localization algorithms based on range-based and range free localization schemes. The surveys show that many algorithms are now reaching cm error like parametric looping techniques. For the future work, the noise, network coverage, and lower bounding must be adopted for each system.

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