# A Survey on 3d Localization in Wireless Sensor Networks

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**Abstract:**
WSN is used in many recent trends in wireless application, where its nodes needed to localize him before sending any data. Nodes are defines their coordinates in localization process, through coordinates they localize himself. There are various algorithm proposed in localization based on 2D works on two plane, it provides accuracy but in real world needed all three planes for correct estimation and more accuracy in localization. The 2D works on flat terrain, we need to deploy WSN in harsh terrain also, so we needed to define algorithm on 3D basis for providing better accuracy and decrease the error of estimation and it provide a real world view. This paper works on localization of node using 3D and its algorithm.

**Keywords:** Beacon Node, Localization Algorithm, Unknown Nodes, Wireless Sensor Networks.

## 1. Introduction

Wireless Sensor Network consists of autonomous devices which called as node. Node is used to sense or monitor the environment, where it gathered the data through it, and send to the user through base stations. Its applications used in military as battlefield surveillance, habitat monitoring, environmental monitoring, and health application etc. Sensor network send the data to neighbor node or base station, but before it they need to know their own location, because the data have no meaning without location information from where the data is coming. Nodes are large in numbers it's difficult for base station to calculate the node position, so it need for individual node to send the location information with their collected information, form it provide exact location information to the user. Therefore, node needed to localize himself. The term "Localization" means to find the exact location in any geographical area with the help of references node.

Localization can be done earlier by using manual configuration and by GPS system. In manual configuration localization is done by human interaction and calculation. Where it deploys by using human being and calculation is done through it. But in real world human interaction is not always possible just like in military field, we need airplanes for deployment and the calculation is not always correct. Another is GPS system, which is done by satellite. It is not feasible for all nodes because by using GPS its antenna increases the sensor node size factor, but Sensor nodes are required to be small. The power consumption of GPS will reduce the battery life of the sensor nodes and also reduce the effective lifetime of the entire network; cost factor of GPS is also increases in the network. Also In the presence of dense forests, mountains or other obstacles that block the line-of-sight from GPS satellites, so GPS cannot be implemented. Therefore we need to implement a localization algorithm for every node. Localization algorithm uses the reference node, just as neighbor node and anchor node (which known their position earlier with the help of GPS) for localization. In localization algorithm mostly works on 2-dimensional plane, i.e. x and y plane. In a 2D system, the process of estimation is less complex and requires less energy and time. In 2D plane provide good accuracy is on flat terrains and is difficult to estimate in harsh terrains. It provides accurate distance when more node density and anchor nodes are present. By using 3-dimensional plane added one extra plane called as height i.e. z plane, concept is to it provide more accurate result using height. It can be used in harsh and hilly terrains to provide good accuracy in it. Using 2-dimensional algorithms on a system the position estimate by using point in the plane i.e. x and y plane, where the x and y coordinate are the same as the real position of the surface and altitude is fixed. But when mapping these estimated positions to the real world an error can occur, because it consists of all three planes. Any angle between the reference plane and the ground where it present result may be an error during mapping. By using a localization system for 3D this problem is eliminated completely.

## 2. Literature Survey

WSN contain few nodes who known there location earlier known as anchor or beacon node through it unknown node known's their position. In their some methods and algorithm are proposed for localization using anchor node.

### 2.1 Localization Method

In a 2D space, three anchor nodes are uniquely determine a coordinate system. In a 3D space, four anchor nodes are required. In 3D localization same method uses as define in 2D. Range-based and range-free method is defined for localization process. In which range-based provide point-to-point information with reference node. It provides higher accuracy, but it need additional hardware and through it needed continuous update of information. In there it increases size and cost. Range-free

scheme is used where no additional thing needed, node organize by own self. On comparison range-based provide better accuracy, but it is affected by obstacles and through it accuracy is decreases. There are some techniques is present for localization i.e. distance, angle and position techniques. It is done by using anchor or anchor-free scheme. Some range based schemes are ToA, TDoA, AoA, RSSI, lateration, and angulation method is used. Range-free schemes are Hop Count, APIT. Techniques are defines in localization is as follows:

**1) Position Computation:** Calculation is based on anchor node position from it estimate his own position.

**1.1) Lateration:** In 2D three or more non collinear anchors node are present whereas in 3D four or more non collinear anchor nodes are present and position calculation is done through this non collinear anchor node and estimate the location using the calculated value.

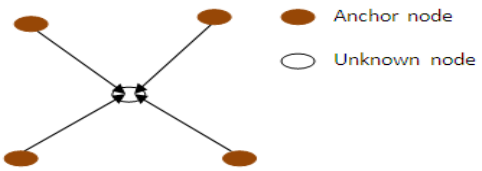


Fig. 1 Lateration techniques in 3D localization using four nodes

**2) Angle measurement:** Calculation is done using information about angles instead of distance, for determining the position of an object.

**2.1) Angle of Arrival (AoA):** Nodes uses Omni-direction antenna. It estimate angle with the help of known reference axis and with signal is send to another node.

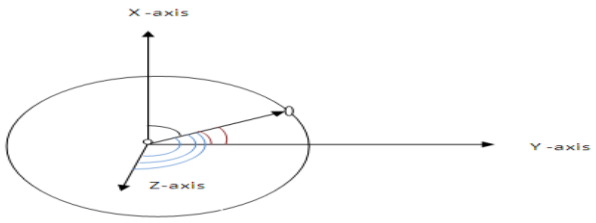


Fig. 2 AoA techniques in 3D localization

**3) Distance measurement:** It uses the anchor node or position of known node for calculation where it uses three anchor nodes in 2D whereas four anchor nodes in 3D.

**1) Received Signal Strength Indicator:** RSSI is a measurement of the signal power coming in a received node. It calculates distance using received signal. Advantage is easy to estimate. Main drawback is the power is decrease when the node present at long distance. Power strength is fading in distance. It is also affected from obstacles. Accuracy is affected from it. Good accuracy is in less distance.

**2) Time of arrival:** This uses a packet for sending from the anchor node to other node. Packet consist of time when it was transmitted, in there the perfect clock synchronization needed between the nodes. The distance formula is calculated between them,

i.e. Distance= speed * time,

Where time is the difference between one node to other node and speed of light is used here because the packet travelled with the speed of light. The advantage of using ToA it is not affected from fading of signal, but if synchronization between the nodes is not their then it cannot be useful.

**3) Time different of arrival:** In TDoA, distance measurement depends upon the difference in time between two waves, or one wave with two destinations. ToA uses two frequency and estimate distance through it. One is radio frequency another is ultrasonic frequency. If unknown node uses one frequency signal, then source sends same RF signal to two different anchor nodes. These two known nodes calculate the difference of time arrival of the signal and calculate the distance between themselves and source node. Similar process used in ultrasonic frequency. If unknown node use two different signal then two destination

nodes are not required only one destination can calculate distance using two different signals. Node sends RF and ultra sonic signal at same time. But known node will receive these two signals with time difference because speed of RF signal is higher than ultrasound signal and calculate difference of time of two signals receive with time difference between them.

$$\text{Distance} = \Delta t * \Delta S$$

Where, $\Delta t$ is the difference between sending and receiving signal between two nodes. $\Delta S$ difference in two signal received by other node.

$$\Delta S = (s1 * s2)/(s1 - s2)$$

**4) Hop Count:** It calculates using number of hop receive the signal by the sender. The number of hop receive the signal is calculate the distance between them. Hop counting techniques is used in range-free method.

**2.2 Localization Algorithm**

For any nodes localization first it is classified into two categories.

**1. Centralized localization:** In there basically one central base station is present for computation. Disadvantage is overhead increase and cost also increases.

**2. Distributed localization:** In their computation are done by own self and node communicate with each other to get their position in the network.

There are many algorithms defines in localization process in 2D WSN and few work have done on 3D WSN and we need 3D localization for providing accuracy and improving positioning error in harsh as well as flat terrain areas.

**1) New 3-dimensional DV-Hop Localization Algorithm:** It expanded the traditional range-free DV-Hop algorithm in to 3D-space. It divide into three steps as follows:

i. Computing the minimum hop counts between the unknown nodes and the beacon nodes: Mobile agent is used for localization, all beacon nodes sent the mobile agent to the other nodes, and mobile nodes recorded the coordinates of the beacon nodes and the number of hops between two nodes. The nodes only saved the mobile agent whose hop counts is the smallest among them, and discarded others.

ii. Calculating the average per-hop distance and measurement error: In it calculated the average per-hop distance of the beacon nodes, and dealt with the measurement error of the beacon nodes. Broadcasted this value in the whole network, the unknown node saved all the average per-hop distance of the beacon nodes which it can receive, and forwarded to the other neighbor of the nodes, then used these average per-hop distances estimate using previously saved hops information to calculate the distance between the beacon nodes.

iii. Calculating the average per-hop distance of the unknown node: If extended the DV-Hop algorithm to the 3-D space simply, then the unknown node will only save the first received average per-hop distance of the beacon node, so that only the information of the most recent beacon node to be used.

**2) Novel Centroid Algorithm for 3D:** This scheme needs no additional hardware support and can be implemented in a distributed way. This algorithm derives a novel node localization method for 3D WSNs. It uses the developed in earlier implement Centroid algorithm. In there the Centroid theorem uses the coordinate-tetrahedron in the volume-coordinate system which acts as a key component of in estimation. All anchors send their positions information to all unknown nodes within their transmission range. Each unknown node collects all the beacon signals from various reference points after it select randomly four anchor nodes in range to form a series of tetrahedrons. It uses the proposed Centroid theorem of coordinate- tetrahedron in the volume-coordinate system to calculate the barycentre (nodes have non-rotating coordinates and present at the centre of two or more bodies) of each tetrahedron. Then we use the average coordinates of these barycentre as the final estimated position of unknown node.

**3) Three-dimensional azimuthally defined area localization algorithm (3D-ADAL):** It proposed an algorithm of three-dimensional distributed range-free localization for WSNs, using a mobile beacon (MB) equipped with a rotary and tilting directional antenna. It is a distributed and energy efficient algorithm and contributes to extend the lifetime of the sensor network. Here uses two types of antenna first is omni-directional antenna which is used by unknown node. Second is equipped with a rotary and tilting directional antenna which is present in MB. The mobile beacon is flight over the whole network and broadcast the beacon messages to the sensor nodes during the localization process. Co-ordinates will be considered for the calculation of the sensor nodes position in its horizontal plane (xy-plane) and the z-coordinates of the MB will be used to determining its altitude. In their virtual beacon message is sent by MB. It divides the algorithm into four phases. The sensor nodes integrate all the received information to firstly estimate its xy-coordinates.

i. Initialization phase: In this phase are established important parameters just as antennas.
ii. Latitude and longitude preliminary determination phase: The algorithm is used to accomplish the position estimation in the local *xy*-plane of each sensor node (local horizontal plane of each sensor node).
iii. Altitude preliminary determination phase: The algorithm performs the calculation of the altitude of each sensor node. To accomplish this task, it focuses in the local *yz*-plane (vertical plane) of the mobile beacon. After a sensor node calculates its preliminary *xy*-position, it uses the information of tilt ($\beta$) in the data packet to determine its altitude.
iv. Refinement phase: It estimation of the position made in the previous phase was performed and continue the process.

**4) The three-dimensional accurate positioning algorithm:** It converts the loss of wireless signal strength between unknown node and beacon node to distance first, and then uses the maximum likelihood estimation method to calculate the unknown node's three-dimensional coordinate according to the beacon node's three dimensional coordinates. It depend of five parameters:

i. Parameter matching: For providing positioning accuracy maximally, any two node's parameters need re-matching before positioning.
ii. RSSI ranging: It Convert the RSSI value to distance between unknown and beacon node.
iii. Role switching between beacon node and unknown node under a particular situation: For 3D positioning, unknown node needs to communicate with four adjacent beacon nodes at least. If the four beacon node is not present then positioning is not completed, so the unknown nodes whose coordinates are known can temporarily act as beacon nodes to complete the positioning.
iv. Signal compensating when there are obstacles between wireless nodes: When obstacles are presents the attenuation degree of wireless signal in barrier is not same with that in atmosphere. It does not meet linear relationship with the distance between nodes any longer, so there is need to compensate the wireless signal.
v. Improving energy efficiency to reduce power consumption.

The three-dimensional accurate positioning algorithm based on Initialization and parameter matching in wireless sensor networks.

**5) Unitary Matrix Pencil Algorithm for Range-Based 3D Localization:** It is a range-based 3D localization methods, it is based on time-of-arrival (TOA) estimation of ultra wideband signal using unitary matrix pencil (UMP) algorithm. This method combines unitary matrix pencil (UMP) algorithm, multilateral localization and three-dimensional Taylor algorithm. UMP algorithm is extended to estimate the time of arrival (TOA) between nodes so as to measure the propagation distance between them. UMP utilizes the centro-hermitian property of a matrix and applies a unitary transformation, which can convert a complex matrix to a real matrix with eigenvectors. This significantly reduces the processing time for real time implementation. As for node position computation algorithm, multilateral localization other than trilateral localization is used here. Taylor algorithm is extended to 3D to solve nonlinear equations. UMP algorithm is extended to the application of UWB wireless sensor network to reduce computational load and improve time resolution. A UMP based TOA estimation algorithm is proposed to measure the distance between two nodes. The estimation results will be used in 3D position computation. In their Channel impulse response (CIR) is modelled is computed and estimated channel and its frequency domain. From it real matrix is constructed and estimation the path delay.

**6) Space distance intersection (SDI):** It is define as a 3D positioning algorithm. It provides two features:
i. Beacon placement strategy: Here mobile beacon is used. Mobile beacon known there location by GPS. Each beacon contains the mobile beacons current location.
ii. 3D position derivation: This process is done by sensor node itself and it divides it into two phases:
Phase1: Each sensor node measures a set of distances with the help of mobile beacon. This algorithm proposed a range based method, so mobile beacon uses UWB signal it is good for multi-path performance and can provide an excellent time resolution. In there it uses TOA techniques for high precision.
Phase2: sensor node derives it 3D position form node-beacon distance measurements by using algorithm, for that SDI is proposed.

SDI is flexible, effective techniques, where computational and accuracy assessment is used. The control points are present who knows their own coordinates in 3D and it used for finding position of unknown node.

Algorithm proposed in 2D there altitude is fixed, not with actual altitude. Through 3D localization it works with real measurement and the algorithm proposed in 3D are provide the unique features and provide good positing error compare to their earlier methods.

## 3. Conclusions and Future Work

Localization is very important in WSN, where to increase the usage of WSN not only in plane surface but in all terrain we need the 3D localization to provide better results. Few algorithms is work on 3D, we need to work more for future to provide more accuracy, flexibility and potential of nodes. In future work need to implement new algorithms and this 3D localization concept also be implement in indoor bases.

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