LS and MMSE based Localization Algorithm for WSNs amid obstacles

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***Abstract*-: In recent years, optimization and Wireless Sensor Networks (WSNs) are extensively used in numerous milieus and hostile topographies. In this paper, we proposed an improved localization algorithm by means of Least square and Minimum mean square error that evolvements with the basic DV-Hop algorithm. The localization error is shortened by our proposed algorithm and improves the localization accuracy of the basic DV-Hop algorithm with minimum number of beacon nodes. The proposed method is simulated and compared with other algorithms such as DV-Hop, ROCRSSI and APIT. The simulation is considered both with obstacle as well as without obstacle.**

***Keywords*-**: WSN, Distance estimation Method, LS, MMSE, DV-HOP, localization, algorithms

I.INTRODUCTION

Wireless sensor networks (WSNs) are molding voluminous deeds in our civilization, as they have turn into the quintessence of ubiquitous tools. WSNs obligate a boundless array of latent requests in both military and inhabitant applications, including robotic land-mine recognition, battlefield investigation, target tracking, environmental observing, wildfire detection, and traffic guideline. In these grave applications the liveliness of sensor location is the common feature shared by all. The core function of WSNs is to detect and report events which can be meaningfully assimilated and responded to only if the exact location of the affair is recognized. Also, in any WSNs, the location information of nodes plays an energetic role in understanding the application context.

A straightforward solution is to equip each sensor with a GPS receiver that can accurately provide the sensors with their exact position. This is not a realistic solution from an economic perspective since sensors are often deployed in very large numbers and manual configuration is too cumbersome. Therefore, localization in sensor networks is a challenging one. In excess of the years, many protocols have been devised to enable the location discovery process in WSNs. In all these literatures, the focal point of location discovery has been a set of specialty nodes known as *beacon nodes*, which have been stated as anchor, locator, or seed nodes. These beacon nodes know their location, either through a GPS receiver or through manual configuration, which provide the location information to other sensor nodes. Using this location of beacon nodes, sensor nodes compute their location using various techniques.

For the essential operation the elementary idea of WSNs is that, the proficiency of each discrete sensor node is limited and the cumulative power of the whole network is adequate. In several WSNs applications, the placement of sensor nodes is accomplished in an ad hoc manner without vigilant arrangement. Once positioned the sensor nodes, they must be able to solitary establish themselves into a wireless communication system. There are divergent kinds of localization approaches and accuracy necessities [1][2]. Localization can be coarsely alienated into two groups: Range-based approach and range-free approach. Range-based approach uses absolute distance estimate or angle estimate, significance that a node can measure the distances from itself to the beacons in a network. In disparity, range-free approach proceeds that a node to measure the direct distances from itself to beacons is unfeasible. A node can calculate approximately its regions or areas only through connectivity and proximity where it stays. Range-based localization be capable of alienated into a further two kinds. The first kind is distance estimation by one-hop; and the second kind is by multi-hop. Localization in WSNs is a multi-hop approach because a node may not converse directly with beacons. A node can send or receive messages to or from beacon nodes only through multi-hop routing. The sensed data may arrive at the destination by the multi-hop. The stability of a routing path is not guaranteed, so the routing path between the data source and data sink may diverge with time. During the multi-hop routing path error may be occurred which may affect the accuracy of localization in WSNs.

Another aspect influencing localization accuracy is the ranging errors. Suchlike kind of ranging approaches is adopted; there will constantly survive some noise in the ranging measurements. Furthermore, since the uniqueness between each transmitter-receiver pair may not the same, this kind of disparity between different motes also pertain negative impact on the accuracy of localization.

1.1 Range based localization:

The capability to measure the range of wireless signal transmissions is the key of range-based schemes. This algorithm is based on distance or angle measurements which are used to estimate the position of node in the network. The Range- based Algorithm usually require expensive hardware (for example: antenna) which is not feasible for WSNs. So the distance estimation is performed using the following techniques RSSI, AOA, TOA and TDOA.

Received Signal Strength Indicator (RSSI) is based on the attenuation of received radio signal with distance. Since the nodes are equipped with radios to perform communications, the distance estimation based on received signal strength has attracted enough attention. Thus RSSI can be used to estimate the distance between the two nodes. RSSI is the cheapest one because it does not require any additional device. The functions of RSSI measurements in its protocol are defined by the physical/medium access control layer protocol of IEEE802.15.4.Standard.Range estimation is then completed by path loss model for RF propagation. However, RSSI based range measurements suffer from noise and link reliability. Efforts were expended to obtain the mapping between RSSI measurements and the associated distances to capture the impact of multipath fading and environmental variations on RSSI measurements in the indoor and outdoor space [3]. Probabilistic model of RSSI range measurements was also introduced in [4] to address the uncertainties and irregularities of the radio communication patterns. In which RSSI value can be mapped to a log-normal distribution of the distance between the two nodes.

Angle of Arrival (AOA): In which a node position is calculated by estimating the angles between neighbour nodes. AOA measures the angle at which the signals are received from anchor nodes. Generally AOA provide more accurate localization. But they are not applicable to WSNs as they require very expensive hardware.

Time of Arrival (TOA): It measures the distance between nodes using signal propagation time or signal's time of flight from source to destination. To estimate TOA, this technique requires precise synchronization between the sender and receiver clocks and high speed sampling of receiving signal. The foremost challenge encrustation TOA based techniques is the difficulty of accurately measuring the time of flight, in the meantime the propagation speed could be tremendously high compared to the distance to be measured. Even though computing distances between each pair of locations is insignificant, the inverse problem of finding the node locations given the pairwise Euclidean distances is far from trivial.

Another common method for range measurement is based on the time difference of arrivals (TDOA). The signal could be radio frequency (RF), acoustic or ultrasound. In this technique the distance between nodes are calculated by sending two different signals which travel at different speeds to their neighbors, and then uses their arrival time difference in propagation times of radio and acoustic signals originated at the same point. Given the time difference of the arrivals, the distance between the sender and the receiver can be obtained by multiplying the time difference by the speed of the ultrasound signal.

1.2 Range free localization:

The range-free localization is being considered as a cost-effective alternative to range-based methods because of hardware limitation of deployment of WSNs devices. Irregularity transmission propagation as well as stringent restriction on cost of hardware has rendered localization a very challenging. The range free localization is more capable and promising to achieve higher localization accuracy without introducing any extra hardware in comparison to range-based technique of localization which depends on received signal strength to calculate absolute point-to-point distance. Range free localization technique deploys information related to network topology as well as connectivity status for valuating location. Low cost, no extra hardware, little communication traffic as well as flexible precision in position estimation is some of the advantageous features of range-free methods. Therefore range-free technique is considered to be most effective solution for the localization issues in wireless sensor network.

In comparison to range-based approach, the range-free techniques facilitate sensor nodes to evaluate their position without depending on parameters like distance or angles. Such methodology normally requires various anchor nodes, that enable position unknown sensor nodes to estimate their position by using the radio. DV-Hop localization, APIT, Centroid localization, amorphous positioning etc. is some typical algorithms of Range free techniques. Based on the algorithm of DV-HOP, sensor nodes estimate their position based on the anchor positions, number of hops from anchor, and also the average distance per hop [5][6]. Amorphous positioning algorithm uses offline hop-distance estimations, improving location through a neighbor-information exchange [7].

Low density of anchors poses a challenge to the multi-lateration approach. In order to apply multi-lateration, DV-distance follows the approach similar to DV-hop. The distances of each hop are summed up to approximate the distance between a non-anchor node and an anchor node that is multiple hops away. The approximated distance is then used in the localization process. One possible variation could be to use the Euclidean distance instead of the multi-hop distance. The Euclidean distance can be computed from geometric relationships and the single hop distances. Therefore, additional neighbors and the corresponding range measurements are needed to eliminate the false estimation. On based on DV-Hop localization algorithm we instruct a new technique which guarantees to reduce the localization error to a massive level. Techniques such as Least Square (LS) and Minimum Mean Square error (MMSE) are linked together with basic DV-Hop algorithm. The proposed method is simulated and compared with other algorithms such as DV-Hop, ROCRSSI and APIT.

The organization of the paper will be as follows: Section 2 presents the DV-Hop Algorithm and improved DV-Hop Algorithm based on Euclidean distance estimation method. Section 3 presents proposed method using LS and MMSE. Section 4 explains Simulation scenarios and Simulation Results. Finally, section 5 concludes the proposed work.

II. DV-Hop Algorithm

The algorithm is divided into two portions. In the first portion, each and every beacon node broadcasts a beacon signal at extreme power so that the signal stretches throughout the network. Initially all the unknown node and the anchor node location with a hop-count value are set to one. Every receiving node withstands the minimum hop-count value per beacon of all beacons it gathers. Beacons with greater hop-count values are defined as stained information and will be ignored. Then the non- stained beacons are flooded outward with hop-count values at every intermediary hop. Through this mechanism, all nodes in the network get the minimal hop-count to every beacon node.

In the second segment, once a beacon node gets hop-count value to other beacons, it calculates an average size for one hop, which is then flooded to the intact network. After receiving hop-size, visor folded nodes multiply the hop-size by the hop-count value to derive the physical distance to the beacon. The average hop-size is predicted by beacon node using the succeeding formula:

$$HopeSize = \frac{\sum_{k \neq j} \sqrt{(x_j - x_k)^2 + (y_j - y_k)^2}}{\sum_{k \neq j} h_{jk}}$$

Where $(x_j,y_j),(x_k,y_k)$ are the coordinates of beacon node j and beacon node k and h_{jk} is the number of hops of beacon node j and beacon node k.

Each beacon node broadcasts its *hop-size* to network in terms of capable saturating. Unknown nodes or sensor nodes collect *hop-size* information, and store the first one. In the similar time, they spread the *hop-size* to their neighbor nodes. This pattern could guarantee that the most nodes receive the *hop-size* from beacon node that has the minimum hops between them. In the end of this stage, unknown nodes estimate the distance to the beacon nodes based on hop-length and hops to the beacon nodes.

Let (x_k,y_k) be the coordinates of the Target node, $(x_i,y_i)(1\leq i \leq n)$ be the coordinates of the Anchor node and $d_j(1\leq j \leq n)$ be distance between the Target node and Anchor node. The actual distance between the Target node and Anchor node is calculated according to the Euclidean formula (A). The nonlinear equation of the formula is as follows:

$d_{A1}^2 = (x_k-x_1)^2 + (y_k-y_1)^2$

$d_{A2}^2 = (x_k-x_2)2 + (y_k-y_2)^2$

$d_{An}^2 = (x_k-x_n)^2+ (y_k-y_n)^2$

To make Euclidean formula as a linear equation, through a nonlinear equation first expand the formula and subtract the next equation. Thus the linear equation as follows:

$2(x_2-x_1).x_k+2(y_2-y_1).y_k=d_{A1}^2-d_{A2}^2+x_2^2+y_2^2-x_1^2-y_1^2$

$2(x_3-x_2).x_k+2(y_3-y_2).y_k=d_{A2}^2-d_{A3}^2+x_3^2+y_3^2-x_2^2-y_2^2$

$2(x_n-x_{n-1}).x_k+2(y_n-y_{n-1}).y_k=d_{An-1}^2-d_{An}^2+x_n^2+y_n^2-x_{n-1}^2-y_{n-1}^2$

This linear equation is in the form of BX = D

Where,

$$B = \begin{bmatrix} 2(x_2 - x_1) & 2(y_2 - y_1) \\ 2(x_3 - x_2) & 2(y_3 - y_2) \\ . & \\ . & \\ 2(x_n - x_{n-1}) & 2(y_n - y_{n-1}) \end{bmatrix}$$

$$D = \begin{bmatrix} d_{A1}{}^2 - d_{A2}{}^2 + x_2{}^2 + y_2{}^2 - x_1{}^2 - y_1{}^2 \\ d_{A2}{}^2 - d_{A3}{}^2 + x_3{}^2 + y_3{}^2 - x_2{}^2 - y_2{}^2 \\ . \\ . \\ d_{An-1}{}^2 - d_{An}{}^2 + x_n{}^2 + y_n{}^2 - x_{n-1}{}^2 - y_{n-1}{}^2 \end{bmatrix} \quad \text{and, } X = \begin{bmatrix} x_k \\ y_k \end{bmatrix}$$

The least square method for BX=D, is given by

$$X = (B^T B)^{-1} B^T D$$

III. Proposed Method

In the proposed model we used two algorithms LS (Least Square) and MMSE (Minimum Mean Square Error) with the dv-hop algorithm through multi hop methodology. In multihop methodology the system terminates the hop and starts a new hop when the next sensor node is not available. The present model uses mobile anchor nodes i.e. all the beacon nodes or anchor nodes present in the network are movable. They keep on moving within the network and transmit the beacon message in regular intervals and also transmit their location. With this information and hop count all the sensors in network will be analyzed using the two algorithms.

Least square is responsible for running the algorithm in loop. In first step it distinguishes between active node and the dead nodes, i.e. the dead nodes are represented by 0 matrix and active node's matrix contain the data therefore the number of nodes in a network is reduced by omitting the dead nodes. Then the data of all the active nodes are sent to the subsequent algorithm which is Minimum Mean Square Error (MMSE).

MMSE first uses Euclidean distance formula and average hops size and estimates the node's position. Then the data is sent to the Least square and the data is stored .Again Least square initiates the localization process and then the mean of the distance of the old coordinates and the new coordinates is set as the new position of the node and is stored as the position .This process is repeated until all the nodes are positioned.

PSEUDO CODE:

```
Public void
For ( every node )
{
Int N,M, networksize, achorloc, sensorloc ;
Declare N(number of mobile anchor node );
Declare M(number of sensor node );
Intnp=20(100%90)
Declare network Size =  length * width
Length=100;
Width=100;
        Initialize     Transmission radii (RT) and
TransmissionArea (AT);
        if(RT<SA)
```

```
                         RT= 2xAT;
  while(insideAT)
Declare anchorLoc(AL)   =[random variable * random variable ];

declaremobileLoc(ml)  = networkSize*rand(M,2);
                       m=1;
}
for (everynode) \\distancecal
{
for n = 1 : N
distance(n) = sqrt( (anchorLoc(n,1)-mobileLoc(m,1)).^2 + (al(n,2)- ml(1,2)).^2  )
}
For (every node)
{
Var al=distance cal;
Var ml= distance cal;
 Declare placement (varal,var ml )
}
For (every port)
{
 Declare sensor transmission(st)
 Declare transmission (cbr)
 Declare transmission (dead)
 Declare status active;
 Declare status dead:
If
{
 St=transmission (cbr);
}
 Then
{ node=active}
Else
{
node =dead
};
For (all active nodes)
{
Declare lms localization err
lms Localization err+ Err = sqrt(sum((mobileLocEst-mobileLoc).^2))\\lms
}
For (all active nodes)
{
Declare mmse
mean_squared_error_mmse=IQbalance(X,H,Y,Rgg,variance);
SNR(n)=SNR_send;
mmse_mse(m,n)=mean_squared_error_mmse;
ls_mse(m,n)=mean_squared_error_ls;
end
end
mmse_mse_ave=mean(mmse_mse);
ls_mse_ave=mean(ls_mse);}
```

IV.Simulation scenarios and Simulation Results

We evaluate the proposed model in terms of localization accuracy and the error estimate in the presence of obstacle and without obstacle considering neighborhood size and compared with the ROCRSSI, DV-Hop, APIT and Amorphous techniques.

4.1 Simulation Model and Performance Measures:

In this section the proposed framework simulation has been carried on Intel Pentium Dual Core E2160 CPU with 1.8 GHz and 2 GB RAM. The architecture is designed in Mat lab 7.2 considering, where 300 sensor nodes and 9 anchor nodes will be distributed randomly in a two dimensional simulation area of size 100 m x 100 m with specific transmission radii (R) and transmission area (r) deployed for mobile anchor nodes. The Wireless communication channel used is Rayleigh multi-path fading which is in the form of the Rayleigh Probability Density Function and the signal used for communication is Binary phase shift keying (BPSK).

We evaluated the performance of the proposed framework with many empirical tests in various scenarios by changing the sensing transmission range radius and obstacle orientation. The simulation is considered both with obstacle as well as without obstacle.

4.2 Simulation parameters:

Figure 1 showing 300 sensor nodes and 9 anchor nodes in the network area of 100m x100m for without any obstacle.

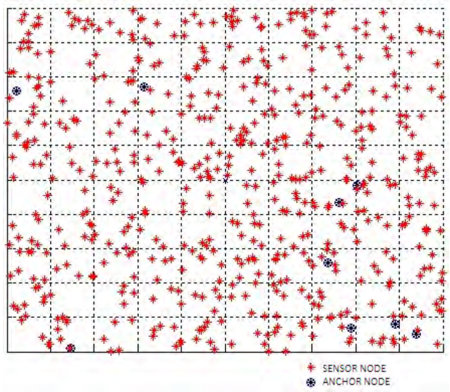

Figure 1 without obstacle

Randomly deployed network with C shape obstacle on a simulation area of 100mx100m is shown in figure 2.

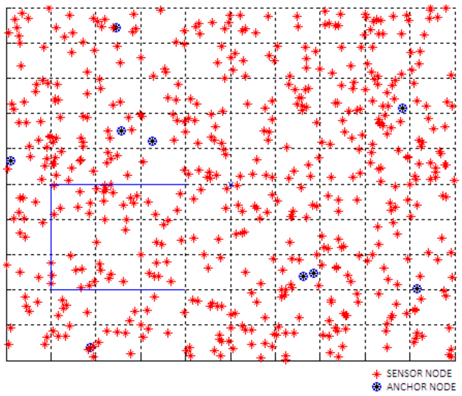

Figure 2 Network with C shape obstacle

Randomly deployed network with triangle shape obstacle is shown in figure 3.

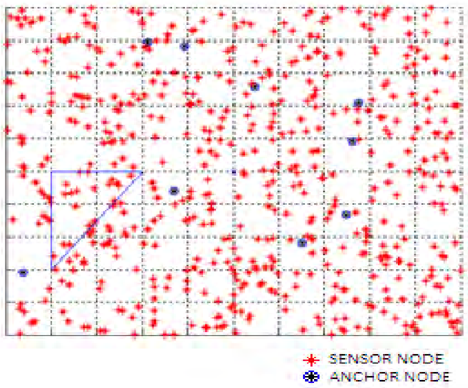

Figure 3 Network with triangle shape obstacle

The Localization Error based on the distance using the proposed algorithms (Least Square and Minimum Mean Square Error) is shown in figure 4.

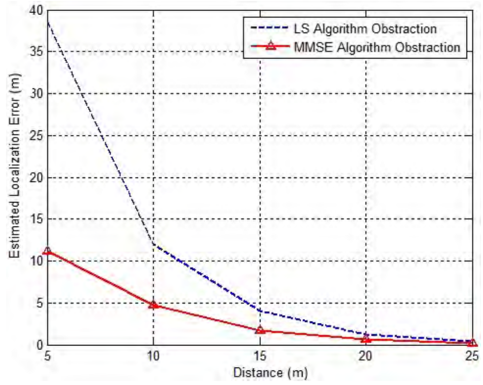

Figure 4 Distance vs. Localization Error

Figure 5 shows the average localization error of 1.465m of the network without any obstacle.

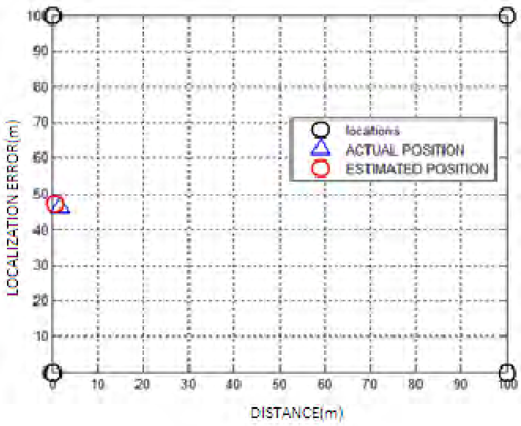

Figure5. Distance vs. Localization Error without any obstacle

Figure 6 shows the average localization error of 3.45 m of the network with triangle shape obstacle.

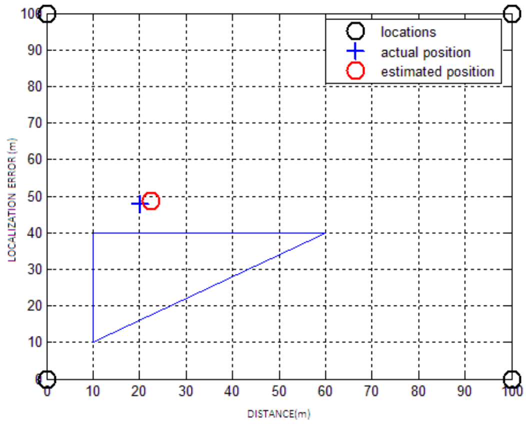

Figure 6 Distance vs. Localization Error with triangle obstacle

Figure 7 shows the average localization error of 9 m of the network with C shape obstacle.

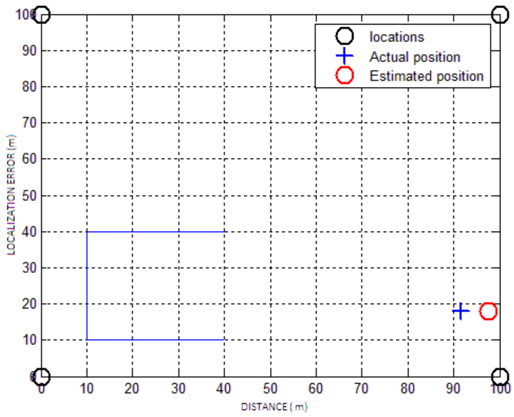

Figure 7 Distance vs. Localization Error with C shape obstacle

Figure 8 shows the performance of the system under different network sizes

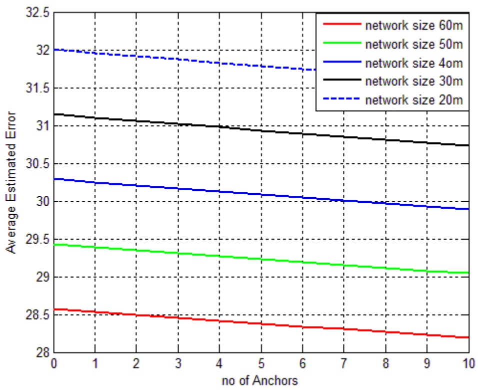

Figure 8Average estimated error versus Number of anchor nodes

The localization error using the proposed algorithm is compared with DV-Hop, ROCRSSI, APIT algorithms shown in figure 9.The Average localization error using the proposed algorithm is 1.245 m to 7.56 m with 64 average number of loops, 20dB signal to noise ratio and the Simulation time is 9ms .From the simulation results we can find that the average localization error for proposed algorithm is lower than that of DV-Hop, ROCRSSI, APIT algorithms.

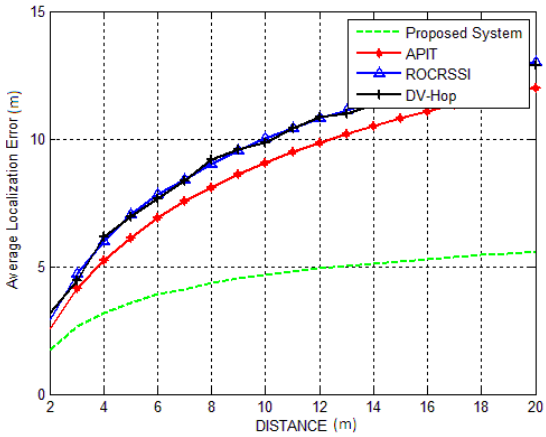

Figure 9 Comparison of Localization Error with proposed method

V Conclusion

In this paper, we have proposed a localization algorithm by means of Least square and Minimum mean square error that progresses the elementary DV-Hop algorithm expressively. The simulation is considered both without obstacle as well as with obstacle for triangle and C shaped obstacles. The localization error is abbreviated by our proposed algorithm and compared with other algorithms such as DV-Hop, ROCRSSI and APIT with least amount of beacon nodes.

VI. References

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