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An Improved Maximum Likelihood Localization Approach for Mobile Nodes in Wireless Sensor Networks using RSSI Technique

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Abstract

The wireless sensor networks based communication system is an increasing research area in the field of wireless communication. It has several advantages such as data sensing and actuating along with various real-world applications such as health-monitoring, environment monitoring, and army applications. In these applications, a large number of wireless sensors are deployed for data sensing. After deployment of these sensors, accurate location of the sensor is desired for efficient data sensing which is known as sensor node localization. Inaccurate locations of sensor collect the faulty information for data sensing which may lead to improper analysis. In order to deal with this, various studies have been presented for wireless sensor network localization. Generally, noisy and inaccurate distance measurement between anchor and sensing node causes this issue and it still remains a challenging task for researchers to minimize the distance measurement error between nodes. Conventional techniques of WSN localization assume that the anchor node positions are known perfectly but fail to provide better localization performance for mobile node scenario. To overcome this issue, we propose a novel approach for sensor node localization using range-based localization methodology. According to this approach, maximum likelihood function based problem is formulated and later RSSI based distance measurement model is developed to minimize the error and find the current coordinates of the nodes. This complete simulation study is carried out using MATLAB simulation tool and we present a comparative experimental analysis performance of proposed approach. The proposed model achieves better performance when compared with existing models of sensor node localization.

INTRODUCTION

Recent advancements in miniature low-power devices have emerged in various real-time wireless sensor communications which incorporates the data sensing, collection, and processing for efficient communication [1]. In wireless sensor network based communication, sensor nodes are deployed in diverse locations in a real-world environment for monitoring the environmental and physical behaviors of that particular location. Sensor nodes are very small in size, lower processing powered by a small battery which causes numerous complexities and challenges in this field of wireless communication. Generally, wireless sensor networks differ from mobile *ad-hoc* network hence the communication protocols which are used in mobile networks may not be applicable to the WSNs. A sensor network is formulated by combining a huge number of sensor nodes which are deployed densely in a predefined field of monitoring. Each sensor node of the network performs the data sensing process for desired monitoring purpose. In any sensor network, data is transmitted from source node to destination node. According to the working process of WSN, the node which collects the data from other node is known as sink node and finally, this data is transmitted to the task manager where task manager performs the operation and assigns a new task to the other corresponding nodes. Moreover, if the sensor nodes are not communicating directly with the sink node the intermediate sensor nodes are responsible for transmitting the collected data.

Wireless sensor networks have various application in real-time systems such as physical and environmental behavior monitoring such as temperature, light, and sound etc., traffic management, healthcare monitoring, underwater acoustic monitoring systems etc. However, wireless sensor networks have various issues which affects the performance of overall communication such as medium access techniques [2], sensor network deployment [3], time synchronization [4], network layers (network layer and transport layer) [5], network security [6], routing [7] and wireless sensor node localization [8]. In this field of WSN communication, node localization is considered as an important aspect which is used for various subjects in WSN communication such as network coverage, node deployment, network routing, location-aware services and tracking etc. Localization is a technique which helps to find the position of the nodes. If the nodes do not have any information about geographical positions of the source node and destination nodes, the data and information may lose and becomes useless. To deal with this issue, GPS (global positioning system) is an effective and simple solution for node localization but recently a large number of nodes are getting deployed and deploying GPS deployment becomes a complex and expensive task for real-time applications. In order to cop up this issue, various techniques have been deployed which are categorized into two main categories as a range based technique of WSN localization and range-free localization for localization. According to the range based localization, it requires node-to-node distance and angles for location estimation process. In [9], range based localization scheme is presented which uses distributed computing in a cooperative fashion. Further, this scheme of localization is improved with the help of position estimation technique. This work shows that media access control scheme (MAC) plays an important role for node localization and estimation. Moreover, MAC helps for energy saving by reducing the packet collisions during communication. Range based wireless sensor node localization schemes have been used widely in various real-time application systems [10,11,12]. Various schemes are present for information extraction from the nodes such as Received Signal Strength Indicator (RSSI), Time Difference Of Arrival (TDOA) [15], Angle Of Arrival (AOA) and time of arrival etc. Yaghoubi et al. [13] presented RSSI based localization scheme for energy efficient WSN communication. Pagano et al [14] also introduced a real-time localization technique using RSSI for indoor localization. Another technique is known as time difference of arrival which is used for range based WSN localization. Li et al. [16] discussed various localization techniques such as time of arrivals (TOAs) and time difference of arrivals (TDOAs). The range-based schemes are more specific and provide better localization accuracy but it requires additional hardware for angle estimation. Similarly, the second approach is known as a range-free scheme of sensor node localization. These range-free schemes do not require any distance or angle information for achieving the localization [17]. However, range-free based approaches are not capable to provide high precision performance and localization accuracy when compared with the range-based localization schemes. In this work, our main aim is to achieve better accuracy performance which can help to obtain the accurate data from the source node and transmit to the destination nodes. Efficient data collection can improve the overall communication considering that low-packet drop rate and low-power consumption routing scheme are implemented in the same network. Although, the performance of range-based scheme can be improved by applying the adaptive computation process. In this work, we present the improved range-based scheme for WSN localization. The main contributions of this work are as follows;

(a) Implementation of range-based localization scheme

(b) Implementation of optimization computation modeling for improving the computation of range-based algorithm

(c) Presenting a comparative approach for localization and concluding the enhanced performance of sensor node localization.

Rest of the manuscript is arranged as follows: recent studies and their impact on the localization accuracy proposed improved range-based localization scheme is discussed in section III, section IV deals with the experimental study and performance and finally, section V provides the concluding remarks.

LITERATURE SURVEY

This section provides the recent studies of sensor node localization for wireless sensor network communication. As discussed before, sensor node localization schemes are mainly divided into two main categories such as range-free and range-based localization algorithm. Here we present a combined study of WSN localization where both schemes have been discussed.

Tomic et al. [18] proposed received signal strength based approach for localization where convex optimization method is also incorporated into the cooperative and non-cooperative approach of localization. In this work, an array of passive anchor nodes is used for collecting the noisy RSS measurement from the nodes which are later used for estimating the positions of the source node. Authors used maximum-likelihood estimator model for achieving the desired solution. Generally, ML estimator minimizes the nonconvex objective function where multiple local optima are present. In this case of multiple local optima, global search implementation becomes a complex task hence a new nonconvex estimator is proposed in this work which is robust to small noise. In [19], Safa et al. proposed a novel approach for sensor node localization along with the minimization of power consumption and memory requirement during communication. According to this process, initially, the task is divided into two section between sensor nodes and base statio2 ns and the anchor nodes are placed in a circle or semi-circle so that it can cover the perimeter of WSN network. This technique helps to improve the localization accuracy and provides significant information of environmental monitoring.

Gui et al. [20] focused on the low cost of implementation of WSN and adopted range-free based localization technique. Several range-free based schemes have been presented but DV-hop (Distance Vector-hop) is considered as a most promising technique for localization of sensor nodes where less than three anchor nodes are present. In this work, authors improved the base DV-hop algorithm known as checkout DV-hop and selective 3-Anchor DV-hop. Checkout DV hop approach estimates the position of a node with the help of nearest neighbor whereas other approach uses three anchor nodes for localization accuracy improvement. In this context of localization, various measurement schemes are also used for localization such as time of arrival, time difference of arrival (TDOA), received signal strength and angle of arrival (AOA) etc. Liu et al. [21] presented RSSI based localization scheme which is used for passive localization. Authors proposed RSS distribution based localization technique for obtaining higher accuracy for sensor network localization. Furthermore, distribution localization and diffraction theory are combined together for reducing the localization error. The study shows that RSS distribution and structure of anchor triangle is efficient for localization of sensor nodes. Similar to the distributed localization approach, Naraghi-Pour et al. [22] presented a novel distributed localization approach which is called as Distributed Randomized Gradient Descent (DRGD). The study shows that if this approach is implemented for the noise-free environment monitoring then this approach is capable to provide the true location of the sensor nodes. On the other hand, in a noisy environment, an error bound is computed and based on the distance measurement, the convergence property is achieved.

Decarli et al. [23] proposed a novel framework for jointly localizing semi-passive and passive objects based on the backscattered response. During this process, signal variations cause signal interference which causes localization error. In order to model the accuracy of tags and passive objects, an analytical Cramér-Rao bound is defined to provide the theoretical localization accuracy. This study also shows the effect of system parameters such as power and signal format, deployment topology, network interference and configuration effect the localization performance. Wireless sensor node localization process suffers from the convex optimization problem which may lead to the improper performance of the localization. Simonetto et al. [24] focused on the convex optimization problem and utilized maximum-likelihood modeling for obtaining the optimal solution. According to this work, a class is presented which evaluates the noise probability density function of the collected distance measurement data. Later, edge-based version of ML convex relaxations class is defined which helps to solve the edge-based convex problem by communicating with the neighboring node. For localization error reduction, Arora et al. [25] presented bio-inspired approach of optimization known as butterfly optimization algorithm. This approach is tested for multiple number of node variation in an iterative process where nodes are varied from 25 to 150 nodes and distance measurement parameters are corrupted by Gaussian noise.

Other than range-based approach of localization, range-free localization schemes also have been adopted in wireless communication. Sharma et al. [26] presented a range-free approach for localization for 3D-wireless sensor networks. This approach uses genetic algorithm based optimization hence it is known as 3D-GAIDV Hop (3D genetic algorithm based Improved Distance Vector Hop). According to this approach, a correction factor is introduced which is used for modifying the average hop size of anchor nodes which is later updated using line search algorithm. In [27] Singh et al. discussed that range-based algorithms are expensive to implement for real-time applications whereas range- free approaches are easy to implement but the localization accuracy and energy efficiency is a challenging task in the range-free techniques of localization. Based on these assumptions, geometry-based range-free localization scheme is implemented where mobile beacon node is used as a reference node. In this approach, three non-collinear beacon points are used for generating an arc type geometry which is used to generate the chords on the virtual circle of sensor nodes. Further, a perpendicular bisector and approximated radius are used for localization of sensor nodes. Localization accuracy depends on the network deployment area which is considered during arc formulation. Anand et al. [28] also focused on the range free localization for wireless sensor networks. In this process, multidimensional support vector regression (MSVR) technique is used for achieving the localization accuracy.

PROPOSED MODEL

This section presents the description of the proposed approach for wireless sensor network localization. In this approach, we present a novel approach which uses a combination of RSSI (received signal strength indicator) based data and information about sensor node deployment. In this process, we deploy first sensor node according to a given known location. Here, sensor nodes subsequently with the neighboring nodes for information exchange which can be received with the help of RF signals. However, RSSI based localization approaches are widely adopted in wireless sensor networks but still, the performance of localization can be improved hence we present an adaptive approach for localization which uses deployment measurements and the RSSI based distance approximation which is computed from the neighboring nodes. The combined information is used for formulating the likelihood function for estimating the exact position of the unknown node. This technique uses two different sources for information extraction where data fusion scheme also can be implemented for improving the localization accuracy. Moreover, we divided this localization methodology into two methods known as unidirectional localization and bi-directional method of localization. According to the unidirectional process of localization, RSSI measurement parameters of previously deployed sensor nodes used by each node whereas bi-directional method considers that the position of last sensor node is known. In this way, the deployed network is capable to establish the communication in both backward and forward direction. Based on these assumptions, we proceed with the proposed approach, initialized with the problem formulation node localization.

a. Localization problem formulation

Here we present a problem formulation for sensor network localization based on the maximum likelihood function modeling. Let us consider that, sensor node $\boldsymbol{s}$ is deployed with the initial estimated node position as P_{ds} whose exact position is considered as P_s which is assumed to be nearby to the initial estimated position P_{ds} with a likelihood value. According to the probabilistic computation model, real and estimated position of nodes have a relationship based on the conditional probability which can be estimated using likelihood function. This likelihood function can be termed as deployment probability function for any unknown node s, given as :

$$\mathcal{L}_{ds}(\mathrm{P}_s) = \mathcal{L}(\mathrm{P}_s; \mathrm{P}_{ds}) = \mathcal{P}(\mathrm{P}_{ds}|\mathrm{P}_s) \tag{1}$$

Where s denotes the sensor node index and d is the measurement of node deployment

Here, P_{ds} is a bivariate normal distribution whose real position is P_s, for this model the likelihood can be given as:

$$\begin{aligned}\mathcal{L}_{ds}(\mathrm{P}_s) &= \mathcal{L}_{ds}(x_s, y_s)\\ &= \frac{1}{2\pi\sigma_x\sigma_y}\exp\left(-\frac{1}{2}\left(\frac{(x_s - x_{ds})^2}{\sigma_x^2} + \frac{(y_s - y_{ds})^2}{\sigma_y^2}\right)\right)\end{aligned} \tag{2}$$

Where σ_x and σ_y denote the standard deviation values which can be realized as $\sigma_x = x_m.c, \sigma_y = y_m.c$ where x_m and y_m are the distance measurement vectors and the error factor after projection on x and y direction is denoted as c.

Let us consider that during communication, a sensor node s is receiving the beacon packets from the node j which is localized in the defined network area. Here, the distance between these two communicating node can be estimated using RSSI measurement parameters as d_{msj} in a noisy measurement. Now, the estimated position of j^{th} node is $\hat{\mathrm{P}}_j$ and similarly, the estimated distance is given as d_{msj}, which can be used for realizing the likelihood function of the position P_s. In other words, this likelihood function can be termed as likelihood function for radio ranging in WSN communication. This function can be expressed as:

$$\mathcal{L}_{rsj}(\mathrm{P}_s) = \mathcal{P}\left(d_{msj}|\mathrm{P}_s, \hat{\mathrm{P}}_j\right) \tag{3}$$

Where j denotes the deployed node index, r denotes radio ranging and m denotes the measurement vector. In general, it is considered that distance measured by RSSI follows Gaussian distribution in nature as $d_m \sim \mathcal{N}(d, (d.e)^2)$ where e is the range error factor. With the help of given distance measurement and radio ranging the actual distance likelihood function can be computed as:

$$\mathcal{P}(d_m|d) = \frac{1}{\sqrt{2\pi}d.r} \exp\left(-\frac{(d-d_m)^2}{2(d.r)^2}\right) \tag{4}$$

Let us consider that the distance between two location A and B is given as $\delta(A, B) = \sqrt{(x_A - x_B)^2 + (y_A - y_B)^2}$ and for any unknown node s and localizing node j, the likelihood function can be given as:

$$\mathcal{P}\left(d_{msj}|\mathrm{P}_s, \hat{\mathrm{P}}_j\right) = \mathcal{P}\left(d_{msj}|\delta\left(\mathrm{P}_s, \hat{\mathrm{P}}_j\right)\right) = \frac{1}{\sqrt{2\pi}\left(d_{msj}r\right)} \exp\left(-\frac{\left(\delta\left(\mathrm{P}_s, \hat{\mathrm{P}}_j\right) - d_{msj}\right)^2}{2\left(d_{msj}r\right)^2}\right) \tag{5}$$

Let us consider that J_s denotes all the communicating localized nodes. However, the ranging and deployment measurements are different from each other hence the overall likelihood function can be obtained by multiplying all available likelihood functions which can be denoted as $\bar{L}_s(\mathrm{P}_s)$ and by taking the natural log of both side of the function, an objective function S can be denied as:

$$S(\mathrm{P}_s) = \frac{(x_s - x_{ds})^2}{\sigma_x^2} + \frac{(y_s - y_{ds})^2}{\sigma_y^2} + \sum_{j \in J_i} \frac{\delta\left(\left(\mathrm{P}_s, \hat{\mathrm{P}}_j\right) - d_{msj}\right)}{\left(d_{msj}.r\right)^2} \tag{6}$$

In order to obtain the position P_s which is used for maximizing the $\bar{L}_s(\mathrm{P}_s)$ and the function S must be minimized. This modeling converts the localization problem into an optimization problem.

b. Sensor network localization

This section describes the complete process of sensor node localization for any given network area. Here, we try to find the position of the node which is transmitting packets to three or multiple nodes along with the node's target ID. Once the data packet is received then the RSSI measurement is performed and the measurement of this data is sent to sink node which uses this information for computing the position of the node.

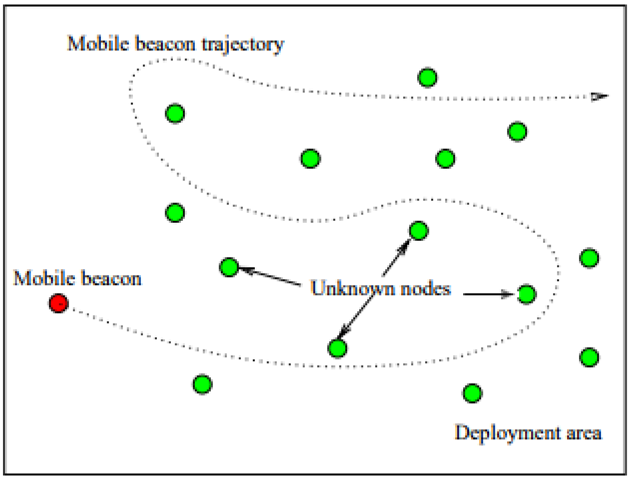

Figure 1. Beacon mobile node assisting for sensor node localization

Let us consider that a sensor network is deployed in the geographical area where mobile beacon travels the complete network during broadcasting the beacon packets. This packet is known as beacon packet which contains the information about beacon node which can be used by the receiving node to infer the location of beacon node with a probability. In this process, RSSI is computed for each received beacon. Based on the RSSI values and beacon position, each node which is receiving the beacon packet formulates a constraint which helps to identify the position of node:

$$\mathcal{C}(x, y) = \mathcal{P}_{RSSI}\left(d\left((x, y), (x_B, y_B)\right)\right) \forall (x, y) \in [(x_{min}, x_{max}) \times (y_{min}, y_{max})] \tag{7}$$

$\mathcal{P}_{RSSI}$ denotes the probability density function of the corresponding distance to the RSSI of beacon packet, $d(A, B)$ denotes the Euclidean distance measurement between two points A and B and the network boundary coordinates are given by x_{min}, y_{min}, x_{max} and y_{max}. Once these constraint parameters are computed then Bayesian inference computation is applied for estimating new position (Pos_{New}) from its old position (Pos_{Old}). This new position computation can be expressed as:

$$Pos_{New}(x, y) = \frac{Pos_{old}(x, y) \times \mathcal{C}(x, y)}{\int_{x_{min}}^{x_{max}} \int_{y_{min}}^{y_{max}} Pos_{old}(x, y) \times \mathcal{C}(x, y)} \forall (x, y) \in [(x_{min}, x_{max}) \times (y_{min}, y_{max})] \tag{8}$$

Here, we consider that initial positions of sensor nodes are given as a constant value at beginning of the sensor network communication. Once the final position of nodes is computed then the weighted average is applied to obtain the best coordinate values, given as:

$$(\hat{x},\hat{y}) = \left(\int_{x_{min}}^{x_{max}}\int_{y_{min}}^{y_{max}} x \times Pos_{est}(x,y)dxdy, \int_{x_{min}}^{x_{max}}\int_{y_{min}}^{y_{max}} y \times Pos_{est}(x,y)dxdy,\right) \quad (9)$$

As discussed before that, this data collection is carried out in the noisy environment hence we further try to maximize the localization accuracy by applying maximum likelihood computation which is used for minimizing the difference between estimated and measured distance. This can be carried out by minimizing the MMSE (Minimum Mean Squared Error) which require three or more number of nodes for computation. According to the proposed approach, sink node finds the similar data with the help of target ID and packet number by collecting the data from sensor nodes. This difference between estimated and measured distances can be computed as:

$$\mathbb{D}_i(x_0,y_0) = d_i - \sqrt{(x_i-x_0)^2+(y_i-y_0)^2} \quad (10)$$

Where x_0,y_0 denotes the unknown coordinates of the target node and d_i is the distance between sensor node and target node. The position of target node can be achieved by applying MMSE along with $\mathbb{D}_i = 0$, hence Eq. (10) can be re-written as:

$$d_i^2 - x_i^2 - y_i^2 = (x_0^2+y_0^2) - 2x_ix_0 - -2y_iy_0 \quad (11)$$

In this equation, we try to eliminate the term $x_0^2+y_0^2$ by applying subtraction from the rest of the equation and it gives terms as:

$$d_i^2 - x_i^2 - y_i^2 + x_k^2 + y_k^2 - d_k^2 = 2x_0(x_k-x_i) + 2y_0(y_k-y_i) \quad (12)$$

Based on these mathematical models, positions can be obtained using Eq. (13)

$$y = Xb$$

$$b = (X^TX)^{-1}X^Ty \quad (13)$$

Where $X = \begin{bmatrix} 2(x_k-x_1) & 2(y_k-y_1) \\ \vdots & \vdots \\ 2(x_k-x_{k-1}) & 2(y_k-y_{k-1}) \end{bmatrix}$,

$$y = \begin{bmatrix} d_i^2 - x_i^2 - y_i^2 + x_k^2 + y_k^2 - d_k^2 \\ \vdots \\ d_{k-1}^2 - x_{k-1}^2 - y_{k-1}^2 + x_k^2 + y_k^2 - d_k^2 \end{bmatrix}$$

and $b = \begin{bmatrix} x_0 \\ y_0 \end{bmatrix}$.

EXPERIMENTAL STUDY

This section provides a complete experimental study of wireless sensor network localization using proposed approach. In this study, we have performed multiple experimental case studies to show the robust performance of the system. The complete experimental study is carried out using MATLAB simulation tool and the considered parameters are depicted in table 2.

Parameter	Value
Number of Nodes	50,100 and 150
Network area	100x100
Anchor Node	4
Mobile Nodes	50,100 and 150

Based on this assumption, the complete simulation study is divided into three cases such as (a) 4 anchor and 50 mobile nodes (b) 4 anchor and 100 mobile nodes and (c) 4 Anchor nodes with 150 mobile nodes.

(a) 4 anchors and 50 mobile nodes

This section provides a brief discussion about the performance of localization for an experimental scenario where 10 anchor nodes and 50 mobile nodes are used. Figure 2 shows a graphical representation of the actual and estimated location of the nodes where black circles denote the location of anchor nodes and the actual locations of the nodes denoted in blue color and estimated location is obtained and drawn in the red circle and the estimated location using existing model is presented in the green gross mark.

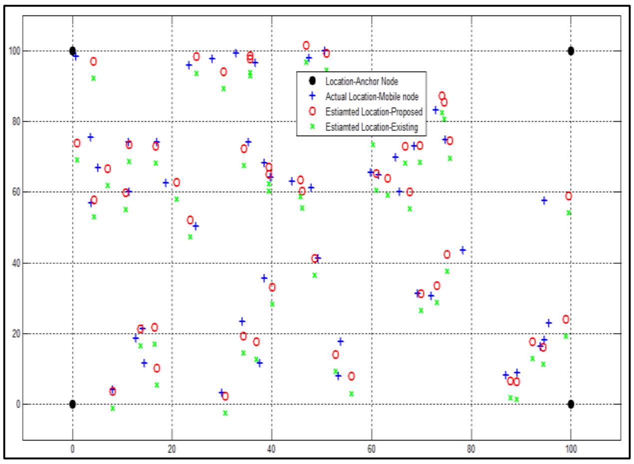

Figure 2. WSN localization for case 1.

This study is performed using Monte-Carlo simulations where various iterations have been used and localization error is measured and compared with the conventional RSSI based algorithm.

Table 3 comparative error performance

Iteration	Error (Proposed)	Error (RSSI)
10	7.89	8.81
20	7.03	8.47
30	6.89	8.21
40	5.59	7.09
50	5.21	6.92
60	4.80	6.40
60	4.67	6.12
70	4.50	5.56
80	4.44	5.30
90	4.30	4.05
100	4.22	4.01

Similar, performance is compared and depicted in figure 3 which shows comparative error in terms of localization error and along with this a linear error performance is also depicted which shows the variation in the localization error.

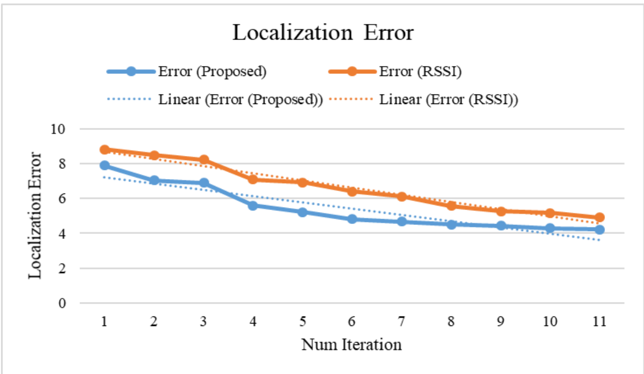

Figure 3. Localization error performance

(b) 4 anchors and 100 mobile nodes

Here, we present the comparative performance by considering 4 anchor nodes and 100 mobile nodes. A similar experimental study is carried out in this process as discussed in the previous sub-section.

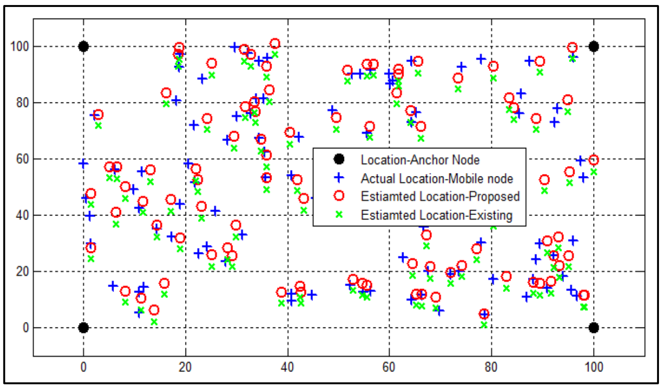

Figure 4. WSN localization for case 2.

For this case, the experimental analysis is and its error values are presented in table 4 where the proposed approach is compared with the conventional RSSI technique of localization.

Table 4 comparative error performance

Iteration	Error (Proposed)	Error (RSSI)
10	11.67	13.60
20	11.32	13.24
30	10.23	12.87
40	8.67	11.63
50	9.11	10.96
60	8.10	10.12
60	7.43	9.58
70	6.65	9.02
80	5.59	8.21
90	4.88	7.38
100	4.19	6.55

A graphical representation of this performance is presented in the figure 5s where the linear error is also computed for both techniques. This performance analysis shows that the proposed approach achieves the better accuracy in terms of sensor node localization when compared with the state-of-art technique.

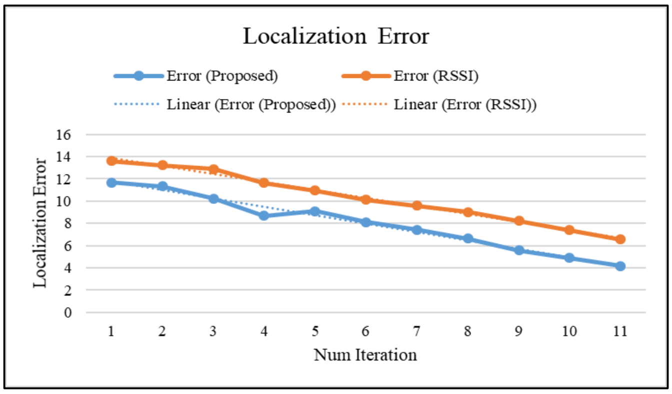

Figure 5. Localization error performance

(c) 4 anchors and 100 mobile nodes

This section describes the performance measurement for 4 anchor nodes and 150 mobile nodes whose localization is depicted in figure 6. In this case, also, we present a comparative performance based on a varied number of iteration as given in table 5. Moreover, a graphical analysis is also presented for the obtained values of localization errors.

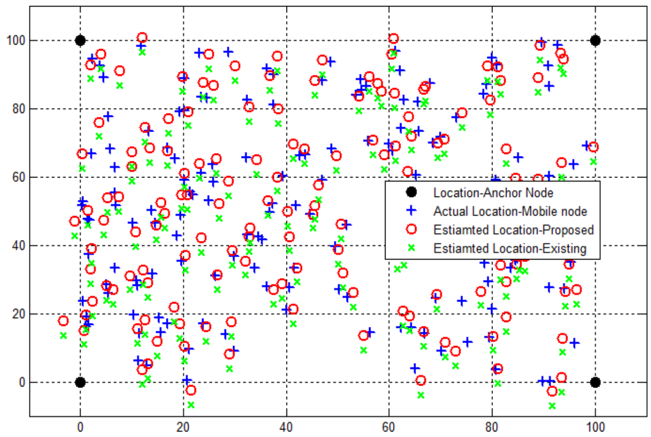

Figure 6. WSN localization for case 3

Table 5. comparative error performance

Iteration	Error (Proposed)	Error (RSSI)
10	13.04	14.92
20	12.30	14.20
30	10.93	13.53
40	9.52	12.59
50	8.22	11.20
60	7.89	10.95
60	6.33	10.03
70	5.58	9.56
80	4.99	8.91
90	4.03	7.61
100	3.33	6.22

Based on these values of localization error, we presented graphical representation of errors with the liner error estimation. The study shows that the proposed approach has a gradual reduction in the localization error whereas existing approach has several spikes due to improper convergence.

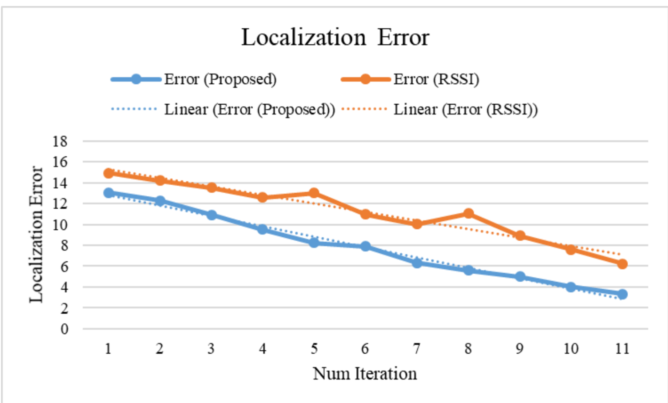

Figure.7. Localization error performance

CONCLUSION

This article presents a scheme for sensor network localization for wireless sensor networks. In this work we have focused on the minimization of distance error between nodes and anchor nodes for improving the localization accuracy. Conventional techniques of localization consider that beacon node positions are already known whereas in this approach we have considered maximum likelihood estimation based approach for node position estimation for mobile nodes. In this approach, first of all localization error based problem is formulated which is further resolved using RSSI based measurement scheme is used to minimize the MMSE with the help of Bayesian measurement. An extensive simulation study is carried out using MATLAB simulation tool which shows that proposed approach achieves better performance in terms of localization accuracy.

REFERENCES

[1] Bhatti, Naveed Anwar, et al. "Energy harvesting and wireless transfer in sensor network applications: Concepts and experiences." ACM Transactions on Sensor Networks (TOSN) 12.3 (2016): 24.

[2] Kausar, ASM Zahid, et al. "Energizing wireless sensor networks by energy harvesting systems: Scopes, challenges and approaches." Renewable and Sustainable Energy Reviews 38 (2014): 973-989.

[3] Younis, Mohamed, et al. "Topology management techniques for tolerating node failures in wireless sensor networks: A survey." Computer Networks 58 (2014): 254-283.

[4] Lévesque, Martin, and David Tipper. "A survey of clock synchronization over packet-switched networks." IEEE Communications Surveys & Tutorials 18.4 (2016): 2926-2947.

[5] Liang, Chengchao, and F. Richard Yu. "Wireless network virtualization: A survey, some research issues and challenges." IEEE Communications Surveys & Tutorials 17.1 (2015): 358-380.

[6] Chen, Zuo, et al. "Trust-aware and low energy consumption security topology protocol of wireless sensor network." Journal of Sensors 2015 (2015).

[7] Zhang, Degan, et al. "An energy-balanced routing method based on forward-aware factor for wireless sensor networks." IEEE transactions on industrial informatics 10.1 (2014): 766-773.

[8] Han, Guangjie, et al. "A survey on mobile anchor node assisted localization in wireless sensor networks." IEEE Communications Surveys & Tutorials 18.3 (2016): 2220-2243.

[9] Pandey, Suman, and Shirshu Varma. "A range based localization system in multihop wireless sensor networks: a distributed cooperative approach." Wireless Personal Communications 86.2 (2016): 615-634.

[10] P. Bahl and V. N. Padmanabhan, “RADAR: an in-building RF-based user location and tracking system,” in Proc. IEEE Joint Conf. IEEE Computer Communications Societies (INFOCOM), Tel Aviv, Israel, Mar. 2000, pp. 775–784.

[11] Salman, Naveed, Mounir Ghogho, and Andrew H. Kemp. "Optimized low complexity sensor node positioning in wireless sensor networks." IEEE Sensors Journal 14.1 (2014): 39-46.

[12] Rashid, Haroon, and Ashok Kumar Turuk. "Dead reckoning localisation technique for mobile wireless sensor networks." IET Wireless Sensor Systems 5.2 (2015): 87-96.

[13] Yaghoubi, Forough, Ali-Azam Abbasfar, and Behrouz Maham. "Energy-efficient RSSI-based localization for wireless sensor networks." IEEE Communications Letters 18.6 (2014): 973-976.

[14] Pagano, Saverio, Simone Peirani, and Maurizio Valle. "Indoor ranging and localisation algorithm based on received signal strength indicator using statistic parameters for wireless sensor networks." IET Wireless Sensor Systems 5.5 (2015): 243-249.

[15] Shen, Hong, et al. "Multiple Source Localization in Wireless Sensor Networks Based on Time of Arrival Measurement." IEEE Trans. Signal Processing 62.8 (2014): 1938-1949.

[16] Li, Xinya, et al. "Contributed Review: Source-localization algorithms and applications using time of arrival and time difference of arrival measurements." Review of Scientific Instruments 87.4 (2016): 041502.

[17] T. He, C. Huang, B. M. Blum, J. A. Stankovic, and T. Abdelzaher, “Range-free localization schemes for large scale sensor networks,” in Proc. ACM Int. Conf. Mobile Computing Networking (MOBICOM), San Diego, CA, Sep. 2003, pp. 81–95

[18] Tomic, Slavisa, Marko Beko, and Rui Dinis. "RSS-based localization in wireless sensor networks using convex relaxation: Noncooperative and cooperative schemes." IEEE Transactions on Vehicular Technology 64.5 (2015): 2037-2050.

[19] Safa, Haidar. "A novel localization algorithm for large scale wireless sensor networks." Computer communications 45 (2014): 32-46.

[20] Gui, Linqing, et al. "Improvement of range-free localization technology by a novel DV-hop protocol in wireless sensor networks." Ad Hoc Networks 24 (2015): 55-73.

[21] Liu, Chen, et al. "RSS distribution-based passive localization and its application in sensor networks." IEEE Transactions on Wireless Communications 15.4 (2016): 2883-2895.

[22] Naraghi-Pour, Mort, and Gustavo Chacon Rojas. "A novel algorithm for distributed localization in wireless sensor networks." ACM Transactions on Sensor Networks (TOSN)11.1 (2014): 1.

[23] Decarli, Nicolo, Francesco Guidi, and Davide Dardari. "A novel joint RFID and radar sensor network for passive localization: Design and performance bounds." IEEE Journal of Selected Topics in Signal Processing 8.1 (2014): 80-95.

[24] Simonetto, Andrea, and Geert Leus. "Distributed Maximum Likelihood Sensor Network Localization." IEEE Trans. Signal Processing 62.6 (2014): 1424-1437.

[25] Arora, Sankalap, and Satvir Singh. "Node Localization in Wireless Sensor Networks Using Butterfly Optimization Algorithm." Arabian Journal for Science and Engineering (2017): 1-11.

[26] Sharma, Gaurav, and Ashok Kumar. "Improved range-free localization for three-dimensional wireless sensor networks using genetic algorithm." Computers & Electrical Engineering (2017).

[27] Singh, Munesh, Sourav Kumar Bhoi, and Pabitra Mohan Khilar. "Geometric Constraint-Based Range-Free Localization Scheme for Wireless Sensor Networks." IEEE Sensors Journal 17.16 (2017): 5350-5366.

[28] Anand, Niharika, Rajeev Ranjan, and Shirshu Varma. "MSVR Based Range-Free Localization Technique for 3-D Sensor Networks." Wireless Personal Communications (2017): 1-18.