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Path Planning For Mobile Beacon Based Iterative Localization

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Abstract*— In this research paper focused on path planning for mobile beacon based iterative localization. Wireless Sensor Network (WSN) is employed to gather and forward information to the destination. It is very crucial to know the location of the event or collected information. Monitoring applications define an important class of applications used in wireless sensor networks. In these applications the network perceives the environment and searches for event occurrences (phenomena) by sensing different physical properties, such as temperature, humidity, pressure, ambient light, movement, and presence (for target tracking). In such cases the location information of both phenomena and nodes is usually required for tracking and correlation purposes. This location information may be obtained using Global Positioning System (GPS) or localization technique in wireless sensor networks. Randomly deployed WSN needs a large amount of GPS-enabled sensor nodes for localization, this necessitates progressive approach. However, nodes with sparse connectivity remain un-localized. In this dissertation, a progressive mobile anchor based technique is proposed for node localization. Initially, sensor nodes are localized using anchors in the neighborhood, and then these localized nodes progressively localized remaining nodes using multilateration. Mobile anchor node moves randomly in field and broadcast position information. It localized nodes with sparse connectivity. Simulations result show that proposed approach localize all sensor nodes with good accuracy.

Keywords*— Wireless Sensor Network (WSN), Global Positioning System (GPS),Ssensor Nodes, Mobile Anchor Nodes And Broadcast, Etc …

I. INTRODUCTION

In this research paper described an introduction to the work, in which first wireless sensor networks discussed then its limitations, advantages, and applications are considered. We also mention why we chose this topic for research. In the end of this section, we will discuss the objective, motivation, approach, problem definition of the dissertation and organization of the thesis.

A. Objective

Localization is a fundamental task in the wireless sensor networks. We consider the problem of locating and orienting a network of un-localized sensor nodes that have been spread over inhospitable locations. In location related system, the findings of sensor's location are the critical step for the efficient and smooth working procedures. The objective of a typical WSN is to detect, track, and classify events in the proximity of the network. We consider networks with beacon nodes (GPS enabled) which are a small proportion of the total nodes, have prior information about their geographical location. We proposed a range-based localization algorithm with power limitations of sensor nodes, the need for accurate results.

The overall objective of this dissertation is to identify the performance challenges for localization algorithms in wireless sensors and to evaluate the existing localization protocols.

The specific goals of this research include:

- To study localization algorithm proposed for wireless sensor networks.
- To understand and analyze the iterative localization algorithms. In presented work, nodes with limited connectivity are often unable to determine their location in the network. It can mitigate using a mobile beacon. The mobile beacon needs to follow a path that should cover maximum sensor nodes as soon as possible.

To propose an iterative localization technique using mobile node follow a zigzag path that should maximize the localization of nodes as well as their accuracy and takes less time to complete the process.

B. Motivation

A Wireless Sensor Network is commonly a relatively large-scale network of expensive, energy limited devices. For a sensor node in a WSN, location information and maybe the position of the neighboring node is essential for successful operations. In geographical routing, data transmission for a node to other nodes needs a fine cooperation among nodes to consume a small amount of energy and to deliver sense data as soon as possible. A sensor node chooses a shorter way to the sink node if it knows the geographic position of itself and its neighboring nodes. Furthermore, most of the applications need to know positional information of the sensor nodes and the events. For instance, a fire monitoring application of WSN must get a line and inform to the sink node about the location of a probable fire. Using GPS devices is the simplest and easiest way to obtain the coordinates of a sensor node; nevertheless, because of a certain distinguishing characteristic of GPS devices which are the requirement in sensor networks requirements, using it in all sensor nodes is not a possible way. These characteristics of using GPS include relatively high cost, high weight, and debatable accuracy of GPS equipment in certain way. To get over GPS Limitations, many localization techniques have been developed for sensor networks which do not depend on the GPS devices bare. In these localization techniques, a few nodes, called beacons, is equipped with GPS devices and help other nodes to determine their position. Many methods have been proposed for localization of static WSNs. In static WSNs, Nodes are static and do not have mobility; in consequences, if a node of these networks could estimate its location once, it will not have to repeat localization process again. Nodes in Mobile WSNs may move by external agents like copter, animals movements and robots. Mobility has a contrary effect on localization process. As previous works indicate, movable nodes can help in localization of static Sensor Networks. In general, a localization algorithm needs to concentrate on static WSNs due to the high importance of this issue. Under mobility conditions, the static localization algorithms are supposed to be applicable with some trivial modifications and periodic mobility parameters tracking.

II. Literature Review

Kaur, Pardeep et.al.[2021], In this paper author invented a range-based, distributed method where randomly deployed sensor nodes in the en sing area are localized with the help of single mobile anchor nodes. The mobile anchor node follows an optimal new path trajectory i.e. spiral Pentagon Trajectory by utilizing the application of SSA. This paper proved that SPT has minimum path length as compares to exiting literature work and SSA has not been used before with this path trajectory. The proposed algorithm can be implemented for single-hop/multi-hop range-free localization for a fully mobile scenario. Future work is focused on the hybrid algorithm with different path planning and different optimization algorithm which can be used to gain high accuracy[1]. ***Punyaban Huang, et.al.[2021],***In this paper discussed, MA*-3DDV-Hop algorithm is proposed based on the shortcomings of large deviation and low precision in 3D complex scene. The algorithm combines the improved A* algorithm with DV-Hop algorithm to redefine the hop-count value path of the node, and uses the normalized value to correct the error caused by the average distance per hop. The multi-objective NSGA-II algorithm is used to optimize the estimated coordinates and obtain the optimal solution. In order to test the actual advantages, accuracy, and reliability of MA*-3DDV-Hop algorithm in three different scenes, this paper designs a comparative experiment with different algorithm models. How to build a comprehensive algorithm, intelligent localization according to the needs of the scene, ensure the localization accuracy, and build a complete algorithm system is worth considering[2]. ***Das, Tisan, et.al.[2020],*** In this paper author presented Traversal technique is one of the most fundamental requirements associated with the localization schemes in the wireless sensor network. As the reduction in mobile anchor node decreases the cost associated with the deployment of the wireless sensor network in a manifold, hence optimization of mobile anchor node traversal by minimizing the total traversed path and average localization error has become an emerging field of study. Nonetheless, further research activity is needed in deterministic path planning mechanism so that existing models can be optimized or novel approaches can be proposed which will further reduce the total traversed path as well as the average localization error by further use of various polygonal approach and fine-tuned pattern along with linear traversal scheme[3]. ***Kannadasan ,et.al.[2019],***In this paper author presented the trajectory of Z-curve with dual mobile beacon method is proposed. The study proves that this Z-curve trajectory is able to procure higher range of localization accuracy, reduced time consumption and minimized localization error. Hence it can be said that proposed Z-curve enables accuracy in terms of localization by yielding minimum localization error, when compared to the existing SCAN algorithm. In the future, we will further study the mobile anchor node assisted localization problem, including analyzing the impact of anchor mobility on localization, design an optimal path planning for anchor nodes to improve localization performance, etc[4]. . ***Tsai et.al.[2019],*** In this paper author presented a trajectory named 'M-Curves' for the mobile anchor based localization approach by considering the key features for localization and we adopted DSA to the problem of localization with novel fitness function. Our proposed path planning model assures full coverage, high localization accuracy and localization ratio. DSA optimized the position of the nodes by minimizing the localization error. It is evident from the results that, optimization gives better performance as compared to the traditional techniques. Compared with other static models such as SCAN, HILBERT, LMAT, Z-Curves, our model shows superior results in terms of metrics such as localization ratio, localization accuracy. Though SCAN and HILBERT has comparatively lesser path length, these two models are affected by co linearity problem. Due to which the localization accuracy of the models are high. Z-Curves model resolved the co linearity issue and it has comparatively lesser path length. However, experimental results shows that M-Curves outperforms SCAN, HILBERT, LMAT, Z-Curves models in terms of localization accuracy[5]. **Kulkarni ,et.al.[2019],**In this paper author compared to the other path planning methods, Σ-Scan provides the highest ratio of localization accuracy and coverage to path length. Σ-Scan saves the power of both mobile beacon and sensor nodes. Power-saving is significantly important for sensor network especially when the scale is large. Sensor localization is energy consuming especially when sensor nodes are mobile and dynamically changes their coordinates with time, such as underwater wireless sensor network. Besides, Σ-Scan is easy to implement and more applicable for ROI with arbitrary shaped. Common localization problems, such as accuracy, coverage and collinear problems, are not solved or evaluated in their methods for the arbitrary obstacle-presence environment. However, Σ-Scan still has some constraints. Σ-Scan can only perform ideally in rectangles of which the side length is measured in units of *s*. Σ-Scan can only be used for 2D areas. We aim to solve these problems in our future work[6].

III. PROPOSED ALGORITHM

In this research paper discussed about proposed algorithms. A distributed range-based iterative localization method has been proposed. In this work, two types of sensor nodes i.e. beacon and non-beacon node are deployed in the network. Initially, all non-beacon nodes are localized themselves using multilateration technique. After that, an iterative mechanism is used to localize remaining non-beacon nodes iteratively. Nodes with less connectivity (less than three neighbors) are localized using a mobile beacon. The proposed method consists three phases: Initial, iterative and mobile. In the first phase, nodes with more than two beacon neighbors are localized using multilateration. In the second phase, localized non-beacon nodes are also used for nodes localization with original beacon nodes. In the last phase, a mobile beacon node follow zigzag path and broadcast its position for node localization.

A. Initial phase

At the very beginning, all the beacon nodes broadcast their positional information using beacon packets within their communication range. The beacon packet consists of the beacon node coordinates in global system and the sensor node id. Once a non- beacon node i receives the beacon packet, it stores the beacon coordinate along with the distance from beacon j to node i obtained by received RSSI value. After receiving beacon packet from minimum three beacon nodes, each non-beacon sensor node. In this proposed work calculates positional coordinates using the multilateration method by taking into considering the distance calculated through the RSSI value of the corresponding beacon node and its coordinates as shown in figure 1. After that, sensor node i broadcasts

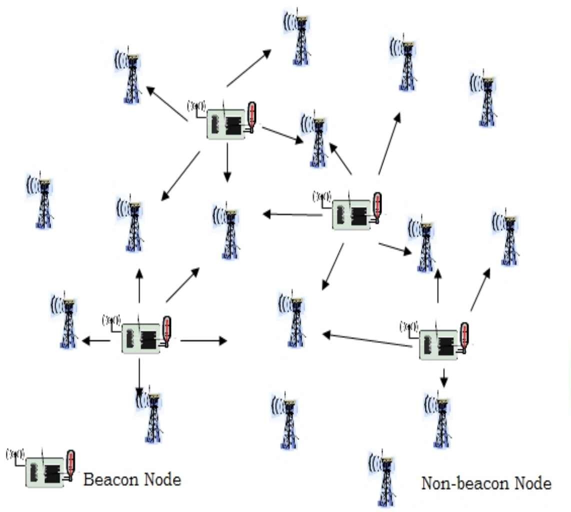

Fig. 1 Initial Phase Localization

Algorithm 1:Proposed algorithm – Initial Phase

There 1: Initialization: Beacon nodes broadcast a beacon packet within communication range (γ).
2: **procedure** INITIAL PHASE
3: **for** each node i **do**
4: **if** Total received beacon packets ≥ 3 **then**
5: Compute coordinates (x_i, y_i) by solving (3.5)
6: Sensor nodes i broadcast computed (x_i, y_i) within γ.
7: **else** wait for beacon packet
8: end if
9: **end for**
10: **end procedure**

B. Iterative phase

In this phase, non-beacon nodes are localized iteratively. Node i with less than three Beacon nodes j uses sensor nodes which are already localized to obtain location coordinates. This is an iterative phase in which each non-beacon node wait for three beacon packet, as soon as it gets required number of the packet, computes their coordinate using multilateration. After that, node i broadcast their estimated coordinates which help to other neighbor nodes to compute their location coordinates. Repeat this process until all nodes gets their location which is well connected to the network; it means has more than three neighbors. The remaining nodes are localized in next phase

5: **if** Total received beacon packets == 3 **then**
6: Compute coordinates (x_i, y_i) by solving (??)
7: Sensor nodes i broadcast computed (x_i, y_i) within γ.
8: **else** Total received beacon packet≥4
9: Update (x_i, y_i)
10: Sensor nodes i broadcast computed (x_i, y_i) within γ.
11: **end if**
12: Call Iterative Phase ()
13: Until each node i obtained (x_i, y_i)
14: **end procedure**

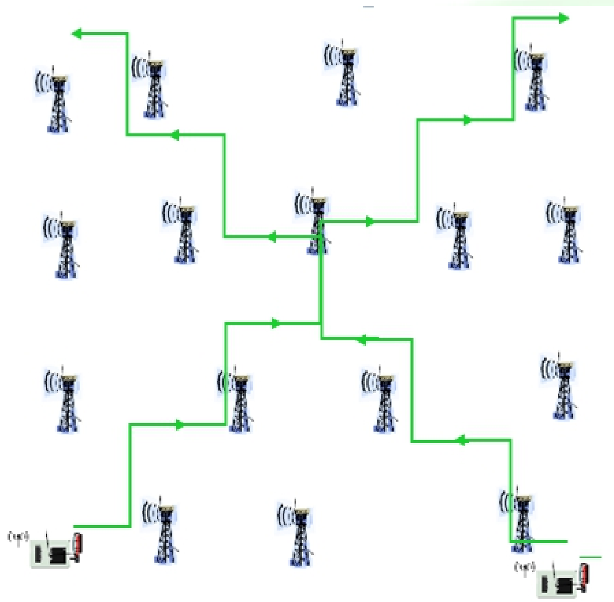

Figure 2(A),Beacon Trajectory – Zig – Zag Diagonally

Algorithm 2:Proposed algorithm – Iterative Phase

1: *Initialization*: Beacon nodes (from beacon nodes and localized non-beacon nodes) broadcast a beacon packet within communication range (γ).
2: **procedure** ITERATIVE PHASE
3: **repeat**
4: **for**each node i **do**
5: **if**Total received beacon packets (from beacon nodes and localized non-beacon nodes) ≥3 **then**
6: Compute coordinates (x_i, y_i) by solving (3.5)
7: Sensor nodes i broadcast computed (x_i, y_i) within γ.
8: **else** wait for beacon packet
9: end if
10: **end for**
11:**end procedure**

C. Mobile phase

A non-beacon with less connectivity is not able to compute their location. To solve this problem we used a mobile node as an beacon, which moves in a predefined path followed randomly in field and periodical broadcast location coordinates. The mobile beacon path planning mechanism presented in this section is named Zigzag path where the basic curve of the trajectory shown in Fig.2 is built based on the Z shape. For each location mobile anchor compute new position using step size (T) defines as

$$T = 0.2*\gamma \qquad (1)$$

where γ is the communication range of the mobile beacon node. New position of mobile node computed by adding T into x or y which depends on the moving direction. The key motivation for designing the Zigzag path, this trajectory has small jumps to overcome the collinear beacons problem and creates a path for transmitting 3 consecutive non-collinear beacons due to this the localization time reduces and maximize the coverage. If the mobile beacon moves on the Zigzag, non beacon nodes have the chance to be localized more accurately while the trajectory is maintained through the border of the deployment area and the whole network field.

Algorithm 3:Proposed algorithm – Mobile Phase

1: Initialization: Beacon nodes (To compute new position (x_{new}, y_{new}) of mobile beacon) broadcast a beacon packet with in communication range (γ).
2: procedure MOBILE PHASE
3: Compute step size T = 0.2*γ
4: Compute new position for mobile node (x_{new}, y_{new}) = (x+T, y+T) or (x,y+T)

IV. SIMULATION RESULT

In this research paper discussed the simulation and evaluation of the proposed protocol - Mobile Beacon Assisted Sensor Localization with Zig - Zag and Diagonal path planning Algorithm in Wireless Sensor Network (WSN), initially we simulate a sensor network with the Efficient Path Planning approach in Mobile Beacon (EPP-MB) technique for performance comparison. Observe the result then we go to our new Mobile Beacon Assisted Sensor Localization with Zig - Zag and Diagonal path planning Algorithm in Wireless Sensor Network (WSN). Then we can conclude that Mobile Beacon Assisted Sensor Localization with Zig - Zag and Diagonal path planning Algorithm in Wireless Sensor Network (WSN) performs better than the EPP-MB algorithm.

Table 1 shows the parameter used in the simulation of proposed system. The whole system is simulated in MATLAB/SIMULNIK environment. For running the simulation here ode23tb solver is used for the time Ts=2μS.

In this proposed work simulated a network of sensors in a 200m×200m sensing field. There are hundred sensor nodes (n = 100) and they are randomly distributed in the field. For doing this, the vertical and horizontal coordinates on every sensor are randomly taken between 0 and 200. The beacon nodes are also randomly distributed. This is a distributed approach; it does not need interruption of sink node. The mobile node can move randomly within sensing field with maximum speed up to ten meters per second.

The table (table no.1) below shows the different values used in our simulation:-

Table 1: Parameter used in Simulation

c	Parameters	Values/Range
1.	Deployed Area	200m×200m
2.	Total Deployed Nodes	100-1000
3.	Beacon Node	10%
4.	Communication range	20 – 30 meters
5.	Error in distance estimation	01% to 20%

In this section, we discuss the performance of the proposed approach. To measure the performance, the proposed approach simulate through MATLAB simulator. We varied the different parameters to observe the performance of proposed mechanism. The parameters are a number of nodes deployed in the field, the number of beacon nodes, the communication range of sensor node, the area of interest and error in distance estimation. The measuring metrics for performance of proposed approach are time taken by a mobile beacon for localization, total nodes localized and Root Mean Square Error (RMSE).

$$RMSE = \sqrt{\frac{1}{N_t}\sum_{i=1}^{N_t}(x_i^{'} + x_i)^2 + \sum_{i=1}^{N_t}(y_i^{'} + y_i)^2}$$

Where N_t is the no. of sensor nodes.

Lets discuss following in order to evaluate performance of Mobile Beacon Assisted Sensor Localization with Zig-Zag and Diagonal path planning Algorithm

1. Number of nodes deployed in the field,
2. Communication range
3. Deployed Area.
4. Error in distance estimation.
5. Time Taken by Beacon Nodes

V. Conclusion

In this research paper focussed on "Mobile Beacon Assisted Sensor Localization with Zig-Zag and Diagonal path planning Algorithm in Wireless Sensor Network (WSN)". It localizes sensor nodes with less error while managing time and reliability for node localization. Firstly, sensor nodes with more than two mobile nodes in the neighborhood are localized using multilateration. After that, in iterative phase, nodes are localized in an iterative fashion. Nodes with less connectivity still not localized because multilateration needs at least three beacons or localized non-beacon nodes for location computation. In "Mobile Beacon Assisted Sensor Localization with Zig-Zag and Diagonal path planning Algorithm in Wireless Sensor Network (WSN)", a mobile beacon moves randomly in sensing field and broadcast their coordinates which enable nodes with low connectivity to localize themselves. "Mobile Beacon Assisted Sensor Localization with Zig-Zag and Diagonal path planning Algorithm in Wireless Sensor Network (WSN)", sensor nodes compute coordinates itself independently which in not centralized unlike [4] where global knowledge of the network topology is required. In this, sensor nodes also update their position as soon as it gets new positional information from neighboring node or mobile beacon node.

WSNs is quite a hot concept in wireless communication meaning that much research is going on and many issues are subjected to be investigated in this domain. Due to the time limitations, our focus was only on the sparse networks for node localization. The future directions for localization algorithm vary from network structure, application types to application demands. Different network designs have different constraints on varying challenges.

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