H-Best Particle Swarm Optimization Based Localization Algorithm for Wireless Sensor Network

Yadevendra Kamal, Kanika Sharma, Vandana

Abstract: ***Discussion of the work, which proposed the idea of virtual anchor nodes for the localization of the sensor nodes, with having the movement of single sensor node in the circular movement with being optimized by the HPSO. For the ranging the RSSI model has been proposed in the algorithm. As a reference node, single anchor node has been used for the localization of whole network. As of the random deployment of the sensor nodes (target nodes), when the target nodes fall under the range of the mobile anchor node, the Euclidean distance between the target node and mobile anchor node is being calculated. After the calculation of the Euclidean distance the two anchor nodes are being deployed with a difference of 60^0angle. Using the directional information the projecting of virtual anchor nodes is done, to which the virtual anchor nodes helps in the calculation of the 2D coordinates. While the calculation the mobile sensor node follow ups the circular path. The mobile sensor node considering at a center of the area marks up distance of its maximum range, and with that distance as a radius its goes for other circular path movement if all sensor nodes don't fell to its range. With its movement at constant velocity the algorithm runs again and again. The performance of the algorithm are done on the factors of the average localization error and convergence time. The problem as of the LoS, with the virtual anchor nodes have been minimized.***

Keywords: convergence error; PSO; HPSO; localization error; wireless sensor networks

I. INTRODUCTION

Wireless sensor networks (WSNs) are established by hundreds of small inexpensive devices. These devices are called as sensors. Sensors are mannered in terms of processing capacities, energy and memory. [1]. Broad scale of applications of WSNs areas such as military targets, monitoring, automated warehouses and disaster relief and it provides solution for variety of utilization [2]. In numerous of these applications, awareness of the location of unknown node is valuable or even vital location. Undeniably, with no knowledge regarding the position of sensor node, gathered information is valueless [3]. Localization is a standout amongst the most imperative subjects in light of the fact that the location and area data is regularly valuable for scope, sending, directing, area benefit, target following, and protections [4].

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Thus, location and area estimation are a noteworthy specialized test for the scientists. In general, localization plays a key role to design efficient procedures in sensor network [5].
The approach to define the positioning and the location value to the sensor node is known as Localization [6]. For the estimation of location and area, where directions and location value are not known at first. It should be possible by the assistance of the absolute position values of a couple of sensors with its respective estimations [7]. The sensor whose coordinate's information is known then it is referred as reference nodes or anchor nodes [8] [9]. Various optimization techniques have been taken into consideration for the localization in WSN [6]. PSO based techniques have been adopted for optimized localization in WSN [4].
The different criterion forms a sensible categorization for location awareness algorithms are shown in Fig. 1.1.

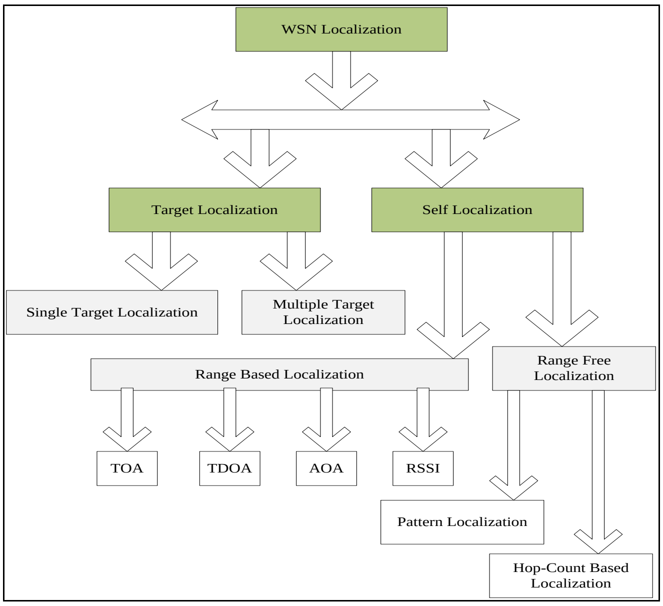

Fig.1.1. Process of Localization in WSN

The importance of determining the node location is as follows: (a)Layout the node origin and its events occurrence in point of occasions [10], (b) Support and find aggregate questioning of sensors, (c) Sensor node routing and answering the sensor system scope during sensing the data, (d)Geographic routing, (e)Target and event tracking.

In sensor network many researches has been proposed and grows new strategies for localization [11]. The major issue of WSN is to reduce the error in their estimations and placing nodes in the network.

Location finding algorithms may be categorized based on many criteria, in terms of basics of designs and choices of implementation [12]. Measurement and the computational are the two stages in existing WSNs location computation approach.

A. *Stage of Measurement*

In the measurement phase, consideration of the node to node distance, connectivity and angle is being done in localization technique. Five categories are into which the classification of the localization techniques can be given to: Received Signal Strength (RSS)

a) Time of Arrival/ Time Difference of Arrival
b) Angle of Arrival
c) Network Connectivity based/ Proximity
d) Scene/Picture Analysis.

a) RSS:

The power measure of the received signal at the receiver end is the Received signal strength indicator. The receiver can find out the distance from the transmitter by using the strength of the received signal. There is no need of additional hardware to compute the RSS, which is the main advantage of this method [13]. But the disadvantage of RSS is, oscillating measured values in case of path loss, mobility environment and fading.

b) ToA:

Time of Arrival (ToA) is also known as 'Time of Flight'. It uses the direct relation between distance and transmission time, when the propagation speed is known. In ToA, both sender and receiver know the time when a transmission starts. The speed of the radio signal is known to us and the time of arrival of this transmission at the receiver can be used to compute propagation time and distance. In ToA based ranging techniques, the clocks at the transmitter and receiver should be synchronized accurately, which lead to extra cost and complexity in this type of ranging method.

c) TDoA:

In TDoA, transmission channel of different speeds is employed. The radio and ultrasound transmission have been simultaneously sent by the transmitter and the arrival of the radio signal is used by the receiver to start measuring the time until arrival of the ultrasound transmission. The arrival time difference between these signals can be used to find out the distance [14]. TDoA method is very accurate under line of sight (LOS) conditions but under some environmental conditions it is very difficult to meet LOS. Also, with air and temperature, the speed of sound in air always varies, which lead to inaccurate distance measurement.

d) AoA:

Angle of Arrival (AoA) is also an option to distance measurement between nodes. AoA is the angle made by two lines, i.e., first line is in between transmitter and receiver and second is the line between receiver and reference direction. The distance measurement accuracy of AoA is more than RSSI technique but the hardware for AoA becomes costly than RSS.

e) Proximity:

This is the easiest technique of measuring length because onl y communication between the sensor centers is necessary for range estimation. Only those locations in its scope are meas ured by a sensors node. For this method, no extra hardware i s needed.

f) Scene/Picture Analysis:

Scene analysis is very distinct from RSS, ToA, TDoA and AoA. The assessment is performed on the grounds of the scene or image evaluation in the image analysis. This method is disadvantageous for additional hardware requirements and difficulty [14].

B. *Computation Stage*

The distance/angle measurements are mixed to achieve th e location of the destination points at the computation phase. The trilateration, triangulation and multilateration are amon g the distance/ angle measurements mixing approaches.

a) Trilateration:

Geometrically, trilateration is the method using the understanding about range between both the goal and the three nearby anchor nodes to acquire the comparative position of the destination node [15]-[18]. Target node 2D co-ordinates are acquired by crossing the three rings. In other words, four nearby anchor nodes must be used to figure out3D co-ordinates. The expansion of alterations is triviable.

b) Triangulation:

Geometrically, triangulation is a method using the understan ding of the corners produced from recognized nodes as regar ds the reference point to obtain 2D node values. Sine and co sine regulations were used to calculate the place of the destin ation node.

c) Multilateration:

Of fact, range distribution in trilateration is almost never ideal, i.e. the convergence of three spheres in particular does not lead to a final level. More than three anchor nodes known as multilateration may be used to solve such an inconvenience. The findings were far greater than trilateration in multilateralisation. By addressing the linear system, its mean square error of multilateration was reduced [19]. Assumption of having knowing the position of the three anchors, i.e., (xi, yi) for i = 1, 2 and 3. (xt, yt) is the position of unknown target node and di for i = 1, 2 and 3 is the distance between target and anchor nodes. The localization algorithms are the mixture of the phases mentioned above. Numerous localization algorithms were categorized in the following verse.

II. CLASSIFICATION OF LOCALIZATION ALGORITHMS IN WSNS

For modern apps over WSNs, sensor locating is becoming an important necessity. Extensive information on the multiple methods for finding the nodes, e.g. range based, range free, anchor dependent, anchor free location systems, etc. is provided in the localisation literature. A message is transmitted by every other sensor node throughout the network.

The above message is stored on both the recipient servers to evaluate the range and to record the hops.

A. Single hop and Multi hop Localization:

The non-anchor node, i.e. the target node to locate, is the one-hop neighbor of enough anchors with known positions in the single hop localization. The destination node that needs to be located in multi-hop places isn't the one hop neighbor of the anchor nodes that are recognized places. Examples of Multi-Hop location include AoA, ToA / TDoA, RSSI, and the few are Single Hop localization and DV-Hop (Distance Vector HOP), APIT (Approximate Triangular location), MDS (Multidimensional Scaling) [20]. The significant disadvantage of the single hop localisation is the lack of scalability and need for high-density base stations. The multi-hop WSN location entry is made by a symmetrical square matrix. The couple smart trip is considered to be the smallest path from one Node to another in this square matrix. Whether it's the range centered or the range controlled distance assessment methods form this range matrix.

B. Range based and Range free Localization:

The two classifications of algorithms of localization are the range based and range-free. Information on the base station spectrum is needed in range-based localization, but no distance data is needed for the location phase in range-free localization [21]-[23]. The range-based technique provides good seed precision, and the range less technique provides gross seed precision. The lengths between the nodes can be evaluated correctly with unique measuring hardware. In range-based localization there are primarily two significant problems. Accuracy of location because of the uncertainty of the sound. Range-free method involves isotropical networks, which are immediately equal to the range among two sensor locations. The analysis of the sensor node co-ordinates is based on data on radio communication between adjacent nodes in the free range of methods. The methods for free range localization are regarded easy and economic rather than range-based methods.

C. Range Free Localization

Some of the range free approaches are given below.

a) **Centroid:** Blusu and Heidemann suggested the Centroid algorithm. The place of anchor nodes of the neighbourhood (minimum three needed) in this method lies within the unidentified node.

b) **Distance Vector-Hop (DV-Hop):** In this algorithm, the number of hops has been quantified between two anchors. By using the information about the number of hops between two anchors, the average length of single hop can be calculated. This estimated hop length is computed by every anchor and this information is propagated into the network. The target nodes can use this hop length for estimation of multi hop range.

c) **Approximate Point in Triangle (APIT):** APIT uses a new strategy to areas. In this area, rectangular areas are split. A node inside or outside these rectangular areas enables a node to live by reducing the region.

d) **Multi-dimensional Scaling (MDS):** The distance among all pairs of nodes has always been quantified to achieve the proximity matrix in a range-free technique. A shortest route algorithm is introduced to a matrix once the matrix is obtained, such as Floyds ' or Dijkstra's algorithm. MDS is a location algorithm with energy efficiency.

III. RELATED WORK

Liu et al. [3] has proposed the ring overlapping has been used for estimation of the node's location. The RORCRSSI doesn't requires the sending of control messages, cost is light of the communication and on anchor only. As of the triangle-overlapping, the ring overlapping demonstrated best for the randomly deployed sensors. The generation of small intersections exhibits to the more accurate location estimation. Under irregular radio propagation the overlapping method is robust. With addition to the triangle three algorithms has been studied ROCRSSI, APIT and APIT+.

Tian et al. [21] presented the unknown nodes are made to choose the three anchor which are most precise to execute the trilateration. For the selective anchor node localization (SANLA), DV-hop algorithm will be implemented for attainment of the average hop and anchor list. Later the process of choosing anchor will begin with reference to the node and later reference node will be considered as the unknown node.

Kumar et al. [18] reported for the proposing application of H-Best Particle Swarm Optimization and Biogeography Based Optimization for the distributed optimal localization of the randomly distributed sensors. The H-Best Particle Swarm Optimization is on the less side of the maturity but has a high convergence rate, were as to the BBO has a robustness build on science of biogeography and employs migration operator to share information between habitants. The comparison has been with the genetic algorithms and the simulated annealing algorithms. Error to noise has been taken into consideration.

Kumar et al. [5] two computationally efficient schemes using the HPSO and BBO has been proposed 3D node localization for range free. To overcome the edge weights between each targets node, non-linearity between received signal strength and distance and neighbouring anchor nodes have been considered for computation of localization of the target node. The edge weights modelled by FLS which being further more optimized by HPSO and BBO for the individually minimization of the location error. Schemes proposed has been in comparison to the centroid and weighted centroid methods.

Sabale and Mini [4] a novel path planning scheme localization has proposed the D-connect, with the minimum trajectory length of all the sensor nodes. The shortest path with minimization localization error for diagonal tracing out of the whole area. The outperformance of D-connect is seen in comparison to LMAT, Spiral, Scan, Double Scan, Hilbert, and Z-curve. The three beacon node non-collinear positions is given by the Diagonal-connect for the location estimation by maintaining the shortest trajectory. Singh et al. [23] for moving target nodes novel 3D localization algorithm using the application of computational intelligence in reference to single anchor nodes the localization has been carried out.

The top layer is being deployed with single anchor node whereas at beneath and middle layers where the target nodes are. For 3D positioning, four anchor nodes are required. The virtual nodes has been proposed with the umbrella projection for the 3D positioning's in an anisotropic network.

As to the projection of virtual anchor nodes has brought down the reduction in the problem of LoS.

Singh et al [9] for non-collaborative, isotropic and range-based WSNs, the Virtual anchor nodes using the applications inspired from the nature has been implemented. The single anchor node utilization has been done for calibrating the 2D positioning of the unknown nodes, the number of nodes localizes, and localization accuracy and scalability are the scales of the comparisons to which efficacy of the proposed algorithms has been virtue. The problem of Line of Sight taken into account and has been reduced.

Tuba et al. [6] RSSI describes the connection between transmitted and received power of the radio signal and the distance between nodes when RSSI is used for the node localization has used the radio signal strength indicator. The flipping ambiguity problem has been dealt with the fitness function and with use more anchor nodes. For solving of the hard optimization, the swarm intelligence and firefly-based algorithms has been used. To biogeography-based optimization and swarm optimization the outperformance have been achieved.

Phoemphon et al. [7] by the technique of fine-tuning with F-based centroid localization method the location inaccuracies by FLS has been improved. The utilization of the virtual anchor has been proposed for the coverage of unknown nodes. All the unknown nodes are in the reach of anchor node and virtual anchor node that as of creation of virtual anchor nodes. Approximation of unknown nodes has been proposed through fuzzy weighted centroid algorithm.

i. H-Best Particle Swarm Optimization

Kennedy and Eberhart [23] created the PSO developmental computing method in 1952. The behavior of moving flying creatures and fish schools is centered on this method. PSO technique uses a set of viable alternatives within a search room by allowing each person to benefit from their own and neighboring location's knowledge. It is an approach that is computationally demanding and also easy to perform. The answers designated particles are used with discrete places in the search space and the objective function equivalent to the discrete places of the particles is measured. Each vector is led to relocate to the highest place and, in addition, collects its finest vector (pBest) and worldwide best (gBest) location in space by obeying laws driven by swarming birds and conduct of fish schools to find a better place. Despite clear evidence that gBest model, owing to the incorporation of fewer computations, has the essence of faster evolution, although it is likely to be caught in the local minima. The swarm is divided into sub-swarms to improve the accuracy and the particle with the highest place in the sub-swarm is appointed as its highest local (lBest). Fast and advanced completion of the lbest model [23]. The suggested PSO version named HPSO having ith particle, that refers jointly to a sub-swarm, appeals to its prior pbest place pi, its local sub-swarm lbest place pl, and its worldwide best gbest place *pg* generally. Envision a d-dimensional search space and ith particle is represented as $[x_{i1,} x_{i2,} \dots, x_{id}]$ within a sub-swarm and its velocity is represented by $V_i = [v_{i1,} v_{i2,} \dots, v_{id}]$. Assume that P i= [p (i1,) p (i2) [, p I d] is the highest place ever seen by a particle. In HPSO, the whole swarm is separated into sub-swarms, let P l= [p (l1,) p (l2,).…, p I d] denote the highest local particle position of each sub-swarm, and P g= [p (g1,) p (g2,)…., p gd] where l and g are particle indices. The particle is iterated according to (1) and (2) in each unit moment.

$$V_{id+1} = wv_{id} + c_1 r_1 (p_{id} - x_{id}) + c_2 r_2 (p_{gd} - x_{id}) + c_3 r_3 (p_{ld} - x_{id}) \quad (1)$$

$$x_{id+1} = x_{id} + v_{id+1} \quad (2)$$

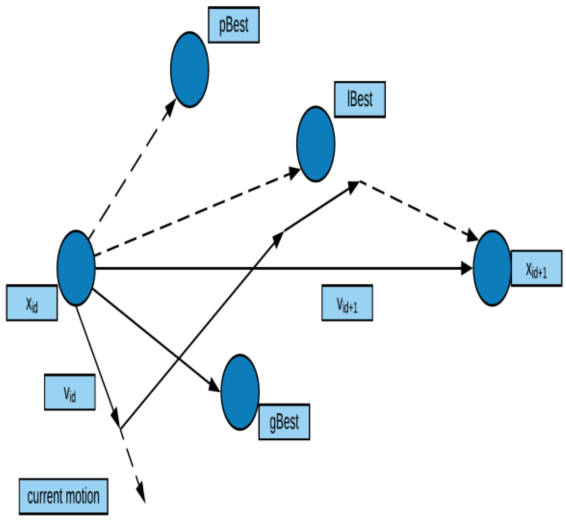

Fig.1.2. HPSO attraction Model

In which w is indicated by inertia and c_1, c_2, and are variables of mental, cultural, and neighbourhood teaching. For quick convergence it was suggested the value of w= 0.7 and c_1=c_2 =c_3=1.4. With the normal coefficients r_1, r_2 *and* r_3 in the spectrum, the particles dynamically adjust the appeal [0, 1]. For quick convergence, Shi and Eberhart have suggested these values. PSO and HPSO provide the fundamental particle appeal of Figs. 1.2 and 1.4. Where, v_{id} and v_{id+1} are the first and most recent velocities of the particle. x_{id} is the starting place of the particles and x_{id+1} the end place of the particles with pBest, lBest and gBest impact.

Where w is denoted by inertia weight and c_1, c_2, and are cognitive, social and neighbourhood learning parameters. The value of w= 0.7 and the value of c_1=c_2 =c_3=1.4 were recommended for fast convergence. The particles randomize the attraction with uniform random numbers r_1,r_2 *and* r_3 in the range [0,1]. These values were recommended for fast convergence by Shi and Eberhart (flow chart in fig 1.3). The basic particle attraction experienced in PSO and HPSO is given by Figs. 1.2 and 1.4. Where, v_{id} and v_{id+1} are the particle's initial and updated velocities.

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x_{id} is particle initial position and x_{id+1} is final particle position with the influence of pBest, lBest and gBest.

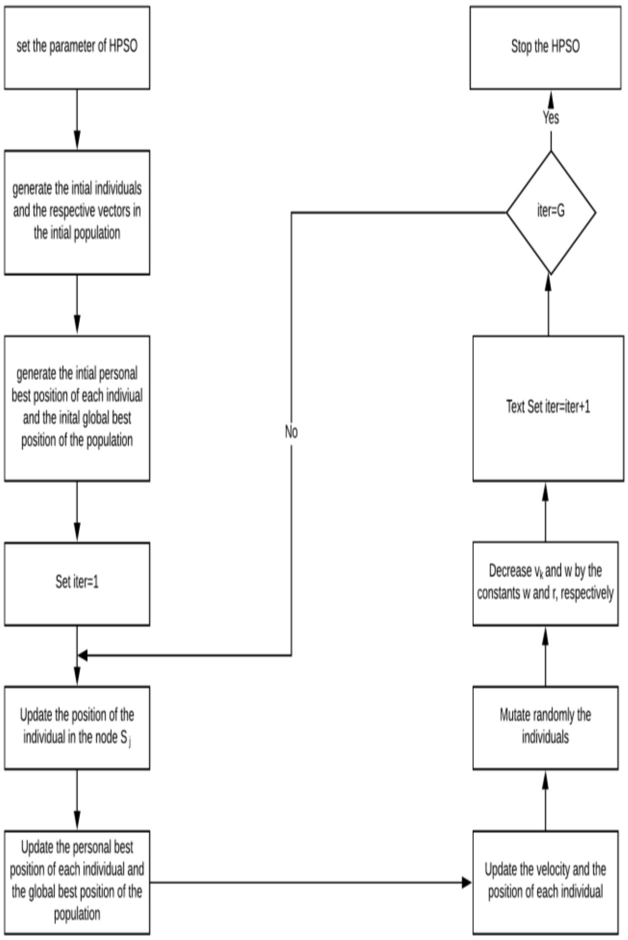

Fig .1.3 Flow chart of Evolution Algorithm

i. Node location optimization using dynamic single anchor node.

The main objective of WSN localisation is to find the coordinates of the N target nodes using the previously known location of the M anchor nodes with distributed single hop range and the pair of wise range information *ith* between the anchor node and the *jth* target node of the total $N_T = (N + M)$ network. To find 2D coordinates of the target nodes, a total of 2*N* unknown coordinates $\theta = (\theta_x, \theta_y)$, where $\theta_x = [x_1, x_2, \ldots . x_N]$, $\theta_y = [y_1, y_2, \ldots . y_N]$ are to be estimated using the known anchor node coordinates $[x_{N+1}, x_{N+2}, \ldots . x_{N+M}]$ and $[y_{N+1}, y_{N+2}, \ldots . y_{N+M}]$ and each target node fall within the radii of three of more anchor nodes are considered as localizable node.

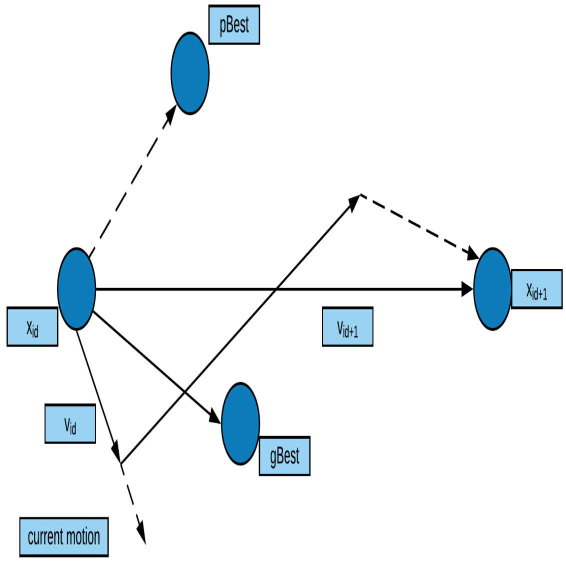

Fig .1.4 PSO attraction Model

A specific portable anchor node is used to locate this algorithm, and the comprehensive algorithm is specified in this chapter. A single vibrant anchor node is used to locate the destination clusters, as mentioned in earlier segments. Objective nodes in the detecting sector are arbitrary. The entire sensor domain is divided into grids, and the base station moves through grids to create a Hilbert curve trajectory. The basic obligation of the shifting anchor node is to provide a beacon message in order to reach its place at the next destination node. Target points stay within the scope of the anchor node, hear to the phone for a specified span of moment and obtain an index node with RSS data. The Euclidian distance between a motioning anchor node and the destination node is computed when a destination node receives data from the RSS. Once the Euclidian distance is calculated, the destination node in the figure is located around the anchor node and it is expected six separate ships at same distance at distinct corners (aspect gap 60 degrees). At least 2 of the anchor towers have been chosen with spatial data. Each node has the same variety of transmissions and comparable settings in this document. This article provides the full localization system stream.

IV. PROPOSED TECHNIQUE

A. Network Model

There are few network assumptions which must be taken into consideration, these assumptions are stated as follow.

a) The nodes are randomly deployed in the network entire area.
b) Those nodes whose location is to be established shall be the target nodes.
c) A mobile node is the anchor node; the user determines the initial position.
d) In this work, instead of moving Hilbert curves as in the established algorithm, the mobile anchor node is encouraged to move in the circular area.
e) The anchor nodes can locate the target nodes only if they are located in the vicinity or in the sensing range of the mobile anchor node.

f) The virtual anchor nodes are basically virtual in the sense that they are used in the network for the localizing the target nodes.
g) The mobile anchor node covers the whole network through the circular motion by changing its position along the circumference of the circle.
h) The physical obstruction in between the nodes is not taken into consideration.
i) Nodes are location aware, however, it is the proposed algorithm which is tested for the localization of the target nodes with the aim of reducing the localization error.
j) The virtual sensor nodes are placed at the equidistant to the mobile anchor nodes at an angle 60 degree. After location determination the virtual nodes are placed at the different positions on the circular path thereby covering the whole network area.

B. Proposed Technique

- A specific portable anchor node is used to locate this algorithm, and the comprehensive algorithm is specified in this chapter. A single vibrant anchor node is used to locate the destination clusters, as mentioned in earlier segments. Objective nodes in the detecting sector are arbitrary. The entire sensor domain is divided into grids, and the base station moves through grids to create a circular curve trajectory. The basic obligation of the shifting anchor node is to provide a beacon message in order to reach its place at the next destination node. Target points stay within the scope of the anchor node, hear to the phone for a specified span of moment and obtain an index node with RSS data. The Euclidian distance between a motioning anchor node and the destination node is computed when a destination node receives data from the RSS. Once the Euclidian distance is calculated, the destination node in the figure is located around the anchor node and it is expected six separate ships at same distance at distinct corners (aspect gap 60 degrees). At least 2 of the anchor towers have been chosen with spatial data. Each node has the same variety of transmissions and comparable settings in this document. This article provides the full localization system stream

V. Simulation and Result

The network is simulated for the parameters defined in the Table 1.1. As the HPSO technique is implemented, therefore there are some initialization parameters for defining the HPSO technique. The network area is taken as 15 X 15 square meter, the number of target nodes used are 50. The numbers of virtual anchor nodes are two.

Table 1.1 Simulation parameters for HPSO and network scenario.

Simulation Parameters	Value
Number of target nodes	50
Population Size	20
Maximum Iteration	100
Inertia weight	0.729
Cognitive learning parameter	1.494
social learning parameter	1.494
Random values r1 and r2	[0 1]
Noise variance	0.1
Network Field	15 X 15 square meter
System Used	Intel Core i3 2:30 GHz processor, RAM=2GB
Number of virtual nodes	2
Angle used	60 degree

- **Performance metrics**

There are basically two performance metrics that are considered in this work to evaluate the proposed protocol as compared to the existing localization technique based on HPSO and PSO. These metrics are explained as follow.

a) Convergence Time

The analysis of the localization algorithm PSO and HPSO is done in a situation focused on mobile anchor. The localization algorithms are stochastic, so that the same application does not have an identical answer. The destination stations are implemented uniformly in the detecting sector and the base cluster moves on a set path i.e., the circular path. The modeling in MATLAB is performed and temporal outcomes are seen in proposed localization .It is defined as the time taken by the optimization technique to give the fittest solution. ACE is the average convergence time that all localized target nodes are considered at the anchor node's specific position. Number of TIR is the destination variables in the specific place of the anchor node. The convergence period of the algorithm should be shorter for mobility-based situations, i.e. convergence should be quick. There is less convergence moment on the algorithms used in this study. It is a very crucial parameter that has a significant role to play in the time critical applications. In Fig. 1.5, shows the convergence time of the proposed technique is shown at different anchor positions of the sensor nodes. The table 1.2 displays the convergence time of nodes at the best location around the circular path, which being traveled by the mobile anchor node. The convergence time taken in the proposed technique, for 16 locations which are chosen in the circular pathway at a random format. The convergence time for all the positions have been mentioned in the table 1.2. The average convergence time for the proposed localization algorithm comes out tube 0.0215s.

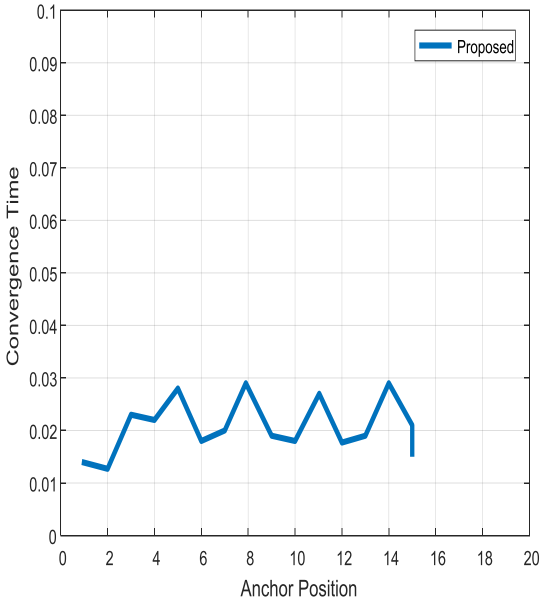

Fig. 1.5 Convergence time vs. anchor position

Table 1.2 The convergence time of proposed algorithm

Anchor Position	Convergence Time (sec)
1	0.014
2	0.012
3	0.024
4	0.022
5	0.028
6	0.019
7	0.02
8	0.039
9	0.019
10	0.018
11	0.026
12	0.018
13	0.019
14	0.029
15	0.022
16	0.016

b) Localization Error

It is observed that with the proposed approach, the localization error is reduced comprehensively as compared to the other protocols. The table 1.3 shows the values of localization error at each anchor node while localization. The average localization error for the proposed technique proves out to be 0.2. The reason behind such improvement is the use of the circular path to cover up the allocated area. The circular path being easiest to settle brought out the covering of the areas whether having the nodes or not without having covering extra. The path selection brought up the scenario of at first selecting the area of which form under the range, then selecting the last point of its range as a radii to move in circular format. Which bringing onto the effectiveness of selecting of anchor nodes more efficiently

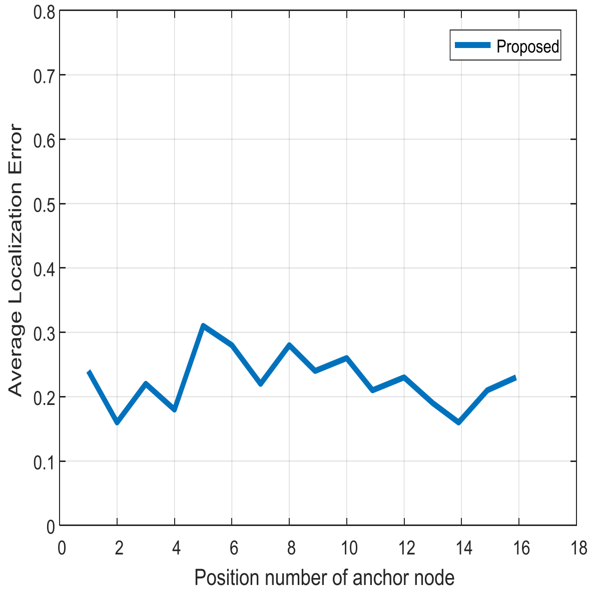

Fig. 1.6 Localization error vs. position number of each node

The fig. 1.6 displays of the localization error on the 16 random locations by the proposed technique, while mobile anchor node following the circular path in the proposed technique. The trend of this error is observed to be more around 0.2 s.

Table 1.3.The localization error at each anchor position of proposed algorithm

Position Number of Anchor node	Average Localization Error
1	0.24
2	0.16
3	0.22
4	0.18
5	0.32
6	0.28
7	0.22
8	0.28
9	0.25
10	0.27
11	0.21
12	0.22
13	0.19
14	0.16
15	0.21
16	0.22

VI. VALIDATION AND COMPARISON

The validation brings on to the point of bringing of the comparison of proposed to the PSO and HPSO. The table 1.4 displays the numerical values of the convergence time of nodes at the best location around the circular path, which being traveled by the mobile anchor node for 16 positions. The convergence time taken in the proposed technique proves to be lesser then the PSO and HPSO techniques.

The 16 locations are chosen in the circular pathway at a random format. In Fig. 1.7 showing performance comparison of convergence time in various techniques, it is evident that the convergence time of the proposed technique is less as shown at different anchor positions in the sensor network. It is further evident that the proposed technique has outperformed the other techniques as it takes very less time.

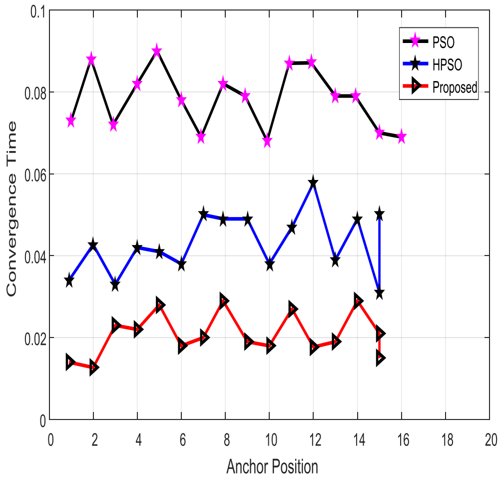

Fig 1.7 Performance comparison of average convergence time in various techniques.

The proposed algorithm proves out to be best at ever location points with least localization error. In the proposed technique the average convergence time proves to be of 0.0215s, of to the average time convergence time of the PSO and HPSO being 0.0787 s and 0.0440 s respectively. Having merit of better performance than PSO and HPSO in average convergence by 72.68% and 51.13% respectively. Fig 1.8 shows performance comparison of average convergence time in various techniques.

The validation brings on to the point of bringing of the comparison of proposed to the PSO and HPSO. In Fig. 1.9 showing performance comparison of localization error in various techniques, it is evident that the error of the proposed technique is less as shown at different anchor positions in the sensor network.

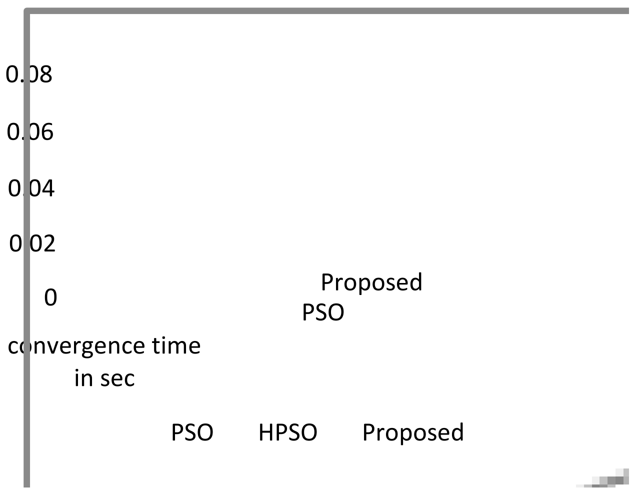

Fig 1.8 Performance comparison of average convergence time in various techniques.

Table 1.4 shows the numerical values of the convergence time

Position Number of Anchor node	PS O	HP SO	PROPOS ED
1.	0. 074	0.0 37	0.014
2.	0. 089	0.0 42	0.012
3.	0. 072	0.0 36	0.024
4.	0. 082	0.0 42	0.022
5.	0. 092	0.0 41	0.028
6.	0. 079	0.0 40	0.019
7.	0. 069	0.0 50	0.020
8.	0. 080	0.0 50	0.039
9.	0. 080	0.0 50	0.019
10.	0. 068	0.0 40	0.018
11.	0. 088	0.0 48	0.026
12.	0. 088	0.0 59	0.018
13.	0. 080	0.0 40	0.019
14.	0. 080	0.0 49	0.029
15.	0. 070	0.0 30	0.022
16.	0. 069	0.0 50	0.016

It is further evident that the proposed technique has outperformed the other techniques. Table 1.5 shows the numerical values of the localization errors by the algorithms at each 16 points.

The proposed algorithm proves out to be best at ever location points with least localization error. The trend of this error is observed to be more around 0.2 as compared to the 0.35 of HPSO and 0.45 of PSO. Proving out that the proposed technique is on less on error part then that of the others. Having merit of outperforming then PSO and HPSO in average localization error by 55.55% and 42.8% respectively. Fig 1.10 shows Performance comparison of average localization error in various techniques.

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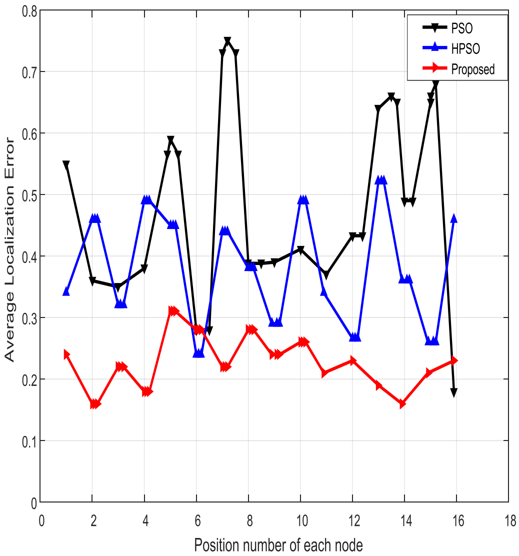

Fig 1.9 Performance comparison of localization error in various techniques.

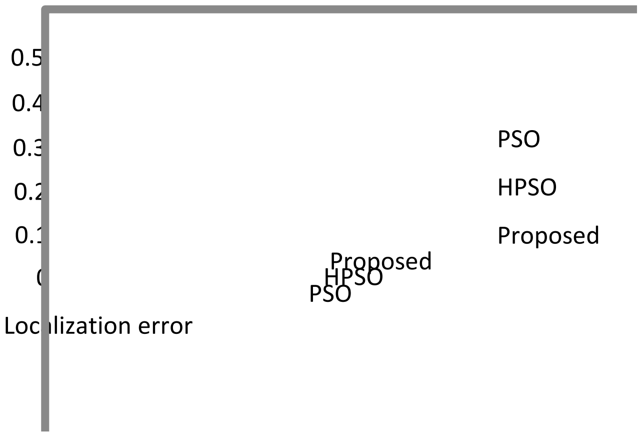

Fig 1.10 Performance comparison of average localization error in various techniques.

Table 1.5 shows the numerical values of the localization errors

Position Number of Anchor node	P SO	HP SO	PROPOS ED
1.	0 .56	0.3 6	0.24
2.	0 .36	0.4 7	0.16
3.	0 .35	0.3 3	0.22
4.	0 .38	0.5 0	0.18
5.	0 .60	0.4 6	0.32
6.	0 .25	0.2 4	0.28
7.	0 .74	0.4 4	0.22
8.	0 .40	0.3 9	0.28
9.	0 .40	0.3 1	0.25
10.	0 .41	0.4 9	0.27
11.	0 .37	0.3 4	0.21
12.	0 .44	0.2 7	0.22
13.	0 .64	0.5 2	0.19
14.	0 .50	0.3 6	0.16
15.	0 .66	0.2 6	0.21
16.	0 .19	0.4 6	0.22

VII. CONCLUSION

. Over the years, WSN has adopted the crucial role of serving the multiple applications that range from the small network area to the large one. The main concern of the researchers has been the energy efficiency issue; however, it is studied that only the energy efficiency is not the solution for the network striking for higher optimal network performance.

Therefore, the localization of the sensor nodes came into existence. Wireless sensor network experiences the random deployment of nodes in the network. It becomes imperative to know the geographical location of deployed nodes along with the information sensed by that node. The node whose location is to be determined is termed as target node. The determination of the location of nodes is done through the minimization of localization error. When the nodes are thought to be deployed with the GPS systems installed on their devices, the cost of the network goes very high. Therefore, there is requirement of an algorithm that detects the locations of the target node without using the GPS system. It is studied that the reference node which is used for this task is termed as anchor node. The mobile anchor node helps in detecting the target nodes located all around the network area.

In this work, the proposed algorithm reports a mechanism in which some of the mobile anchor nodes are deployed with two virtual anchor nodes at an angle of 60 degree as it helps to locate the target node. PSO and HPSO is used for the localization and anchor node is moved through the circular path as compared to the Hilbert curve in other method. The nodes are randomly deployed in the network. However, the anchor nodes are made to move in the circular path along the radius as compared to the Hilbert curve motion of the previous method.

The use of six virtual anchor nodes create complexity, so the use of only two anchor nodes at an angle of 60 degrees in the proposed work, helps in the reducing the complexity of the algorithm by the significant amount. Therefore, the main issue that is being targeted in the proposed work is the reducing the convergence time and also the localization error.

Having merit of better performance than PSO and HPSO in average convergence by 72.68% and 51.13% respectively also in average localization error by 55.55% and 42.8% outperforming then PSO and HPSO respectively is attained. It is observed through the simulation analysis that the proposed work outperforms the HPSO method with six anchor nodes. The localization error is reduced effectively. The convergence time for the algorithm is drastically reduced.

It is because of the circular movement of the mobile anchor nodes that does not follow the empty space in the network which is followed by the mobile anchor nodes in the other work. Furthermore, the proposed work also reduces the number of calculations involved which has helped in the reducing the localization error effectively.

VIII. FUTURE WORK

In future, the proposed work can be extended to determine the energy efficiency issue along with the localization error. The localization error reduction is of primary importance; however, the limited battery resources cannot be ignored. Therefore, if the technique applied for locating the coordinates of the target nodes, can further be applied for the data collection in the network, the network performance could be improved to the great level. Furthermore, as in the proposed work, the anchor node is made to move in a specific pattern, therefore, the mobility for the same can be optimized under different optimization scenarios. The convergence time is of great importance while dealing with time critical applications, therefore, there is further requirement to reduce the execution time for the proposed work.

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