IMPROVED LOCALIZATION IN WIRELESS SENSOR NETWORKS USING WHALE OPTIMIZATION ALGORITHM

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Abstract - *Similar to many technological developments, Wireless Sensor Networks (WSN) have emerged from military needs and found its way into civil applications. Today, wireless sensor networks has become a key technology for different types of "smart environments" and an intense research effort is currently underway to enable the application of WSN's for a wide range of industrial problems. Wireless networks are of particular importance when a large number of sensor nodes have to be deployed, and/or in hazardous situations. Localization is important when there is an uncertainty of the exact location of some fixed or mobile devices. One example has been in the supervision of humidity and temperature in forests and/or fields, where thousands of sensors are deployed by a plane, giving the operator little or no possibility to influence the precise location of each node. The size of an event log file is approximately proportional to the number of events it contains. For easy visualization the events need to be recorded for specific time instants.This report analyses the error and signal strength at number of nodes in a sensor network. Moreover, it improves localization of nodes by using Whale Optimization algorithm (WOA) and compares the existing approach i.e Particle Swarm Optimization (PSO) with it .The error and signal strength improves by using whale optimization algorithm (WOA) , thus increases the accuracy of WSN node localization.*

***Key Words*: Particle swarm optimization, localization, whale optimization algorithm, wireless sensors.**

1. INTRODUCTION

A wireless Sensor Networks (WSNs) form a subset of Ad-hoc networks. Wireless sensor devices have a wide range of application in surveillance and monitoring. Most of the devices or nodes in wireless sensor network are made up of off-the-shelf materials and deployed in the area of surveillance and monitoring [6]. The responsibility of each sensor node is to identify the changes in its particular region or area. The changes are like movement of animals, increase or decrease in temperature or rainfall and these changes are periodically reported to the aggregation point or the central server. The central server or the aggregation server identifies the area with the help of the location reference sent by the sensor node. Initially during deployment each sensor nodes are given their location reference [3]. This is done either manually or the sensor nodes automatically calculate the distance with the help of GPS devices attached to it. Installing a GPS device or manually calculating the location may not be possible in the context of large network because of the excessive cost and work force involved respectively [1]. To overcome this sensor nodes are made to identify their locations with the help of neighbouring nodes. Thus focuses on the localization techniques used by the sensor nodes to identify their location. Several researches are going on in the field of localization to identify the exact location. The location of the nodes plays a significant role in many areas like routing, surveillance and monitoring, and military. The sensor nodes must know their location reference in order to carry-out Location-based routing (LR) [14].

So as to find out the shortest route, the Location Aided Routing (LAR) protocol makes use of the locality reference of the sensor nodes. In some industries the sensor nodes are used to identify minute changes like pressure, temperature and gas leak, and in military, robots are used to detect land-mines, where in both the cases location information plays a key part [11].

Localization is extensively used in Wireless Sensor Networks (WSNs) to identify the current location of the sensor nodes. A WSN consist of thousands of nodes that make the installation of GPS on each sensor node expensive and moreover GPS will not provide exact localization results in an indoor environment. Manually configuring location reference on each sensor node is also not possible in the case of dense network. This gives rise to a problem where the sensor nodes must identify its current location without using any special hardware like GPS and without the help of manual configuration. Localization techniques make the deployment of WSNs economical [7]. Most of the localization techniques are carried out with the help of anchor node or beacon node, which knows its present location. Based on the location information provided by the anchor node or beacon node, other nodes localize themselves [6].

A wireless detector network consists of huge range of sensor nodes that has the flexibility of sensing, computing and transmission knowledge from the tough setting. These detector nodes are randomly deployed within the field as shown in Fig.1.1. These detector nodes are equipped with restricted resources, like for humpback whales there is restricted food .For effective and economical utilization of energy resources of a detector node, numerous communication protocols are often designed.

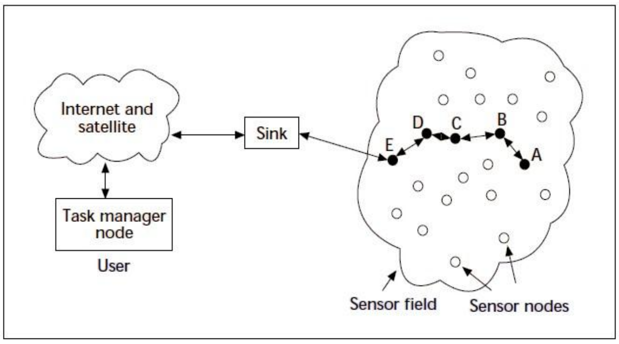

Figure 1.1 Wireless Sensor Network Architecture [10]

There are four main elements of a detector node shown in Fig. 1.2 namely Sensing unit, Process unit, Transceiver unit, EMU.

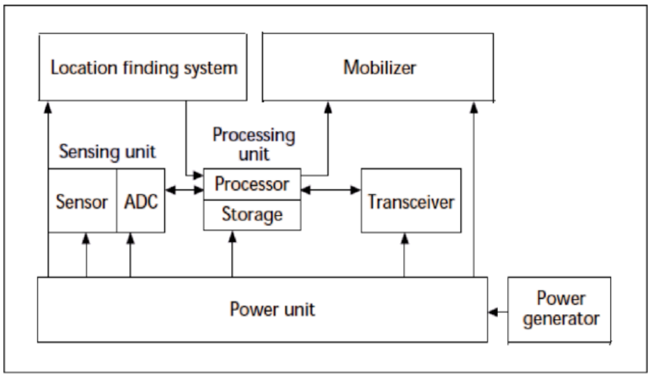

Figure 1.2 Components of a sensor node [10]

1.1 LOCALIZATION

Localization is estimated through communication between localized node and un-localized node for determining their geometrical placement or position. Location is determined by means of distance and angle between nodes. There are many concepts used in localization such as the following [8]:

- **Lateration** occurs when distance between nodes is measured to estimate location.

- **Angulation** occurs when angle between nodes is measured to estimate location.

- **Trilateration.** Location of node is estimated through distance measurement from three n nodes. In this concept, intersection of three circles is calculated, which gives a single point which is a position of unlocalized node.

- **Multilateration.** In this concept, more than three nodes are used in location estimation.

- **Triangulation.** In this mechanism, at least two angles of an unlocalized node from two localized nodes are measured to estimate its position. Trigonometric laws, law of sines and cosines are used to estimate node position [8]

1.2 TYPES OF LOCALIZATION

In most of the localization techniques, localization is carried out with the help of neighbouring nodes. Initially few nodes are made available with their location reference either by manual configuration or using GPS devices. Several localization techniques are discussed as follows. Fig. 1.3 illustrates the different techniques or methods used to identify the location of the nodes. The localization can be classified as known location-based localization, proximity-based localization, angle-based localization, range and distance-based localization. In fig. 1.4the range and distance based localization are categorized separately, though both are same. For range-based localization, special hardware is required to find out the range, however it is not required for distance-based localization [9]

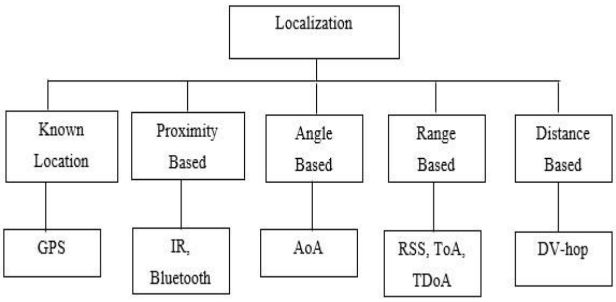

Figure 1.3 Overview of Localization

A. Known location-based localization

In this type of localization, the sensor nodes know their location in prior. This is done either by manually configuring or using a GPS device. Manual configuration of the sensor node is done with the help of GPS. The location of the sensor node is calculated with the help of GPS satellites. Fig.1.4 shows the working of GPS receiver [2].The distance between the GPS receiver and the GPS satellites are calculated using the time taken for the signal to reach the device. Once the distances are known, the GPS receiver uses triangulation or trilateration technique to determine its location. It has a good accuracy with a standard deviation of 4 to 10 meters [13].

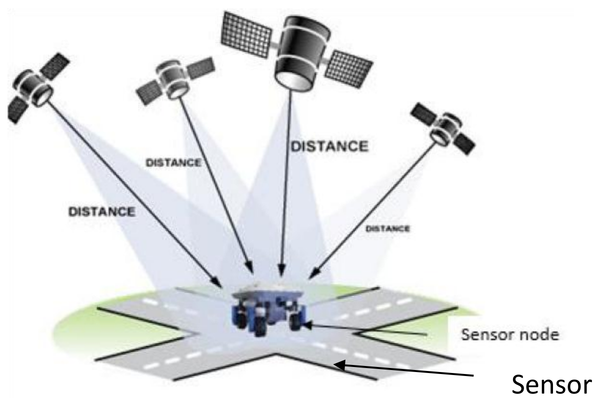

Figure 1.4 Working of GPS receiver

B. Proximity based localization

In this type of localization, the wireless sensor network is divided into several clusters. Each cluster has a cluster head which is equipped with a GPS device [3]. Using Infrared (IR) or Bluetooth the nodes find out the nearness or proximity location. When comparing proximity-based localization with range-based localization, proximity-based localization does not suffer fading [4]

C. Angle based localization

Angle based localization uses the received signals angle or Angle of Arrival (AoA) to identify the distance[3]. Angle of Arrival can be defined as angle between the received signal of an incident wave and some reference direction. The reference direction is called orientation, which is a fixed direction and against that the measurement of AoA is carried out. Using antenna array on each sensor node is the most common approach. Once the AoA is determined, triangulation is used to identify the location co-ordinates.

D. Range based approach

This method uses the range information to calculate the distance between each node. The localization can be carried out with or without the anchor nodes.

E. Distance based localization

Distance based localization technique uses hop distance between the sender and receiver node to identify the location reference. It uses DV-hop propagation method [5] or DV distance propagation method for localization.

1.3 PARTICLE SWARM OPTIMIZATION

PSO is a resilient stochastic optimization method which is dependent on the movement and logic of swarms. Particle swarm optimization has the basic concept of social interaction for solving the problem. PSO developed in 1995 by James Kennedy (social-psychologist) and Russell Eberhart (electrical engineer). It has number of agents i.e. particles that consists of a swarm which is moving around in the search space and finds the best solution[1].Every particle is keeping track of its coordinates in the solution space which are associated with the best optimal solution (fitness) that has been achieved by that particular particle. This value is called personal best i.e. pbest. The best value which is tracked by the PSO is the best value that they got so far by any particle in the next to that particle and this value is known as gbest. The key concept of PSO lies in acceleration of each particle for its pbest and the gbest positions, with a random weight acceleration at every time slot [12].

1.4 PROBLEM DEFINITION

1) The localization problem consists in finding the geographic location of the nodes in a WSN, which can be computed by a central unit or by sensor nodes in a distributed manner.

2) Since most applications depend on a successful localization, i.e. to compute their positions in some fixed coordinate system, it is of great importance to design efficient localization algorithms.

3) The problem is to localize node in different environments using an efficient technique.

4) To find the position of an object or a device, the basic step is to use reference points (also called anchor points) whose locations are known.

1.5 OBJECTIVES

Localization plays an important role in sensor network applications, however, and because of the demanding requirements for low cost, high energy efficiency. Localization is a difficult problem to be solved. So keeping in view this, the following objectives have been proposed:

1) To study different approaches of wireless node localization

2) To Design Algorithm for node localization and improving the localization error while increasing number of nodes.

3) To analyse the proposed and existing approaches on the basis of mean squared error.

1.6 PROPOSED ALGORITHM:

I) Whale Optimization Algo (WOA)

The algorithm used in this paper is whale optimization algorithm (WOA).Whale Optimization is a nature inspired algorithm proposed by Mirjalili and Lewis (in 2016). This algorithm simulates the intelligent hunting behavior of humpback whales. These whales firstly encircle their prey on finding them. They blow a stream of air to create a fizzy net of bubbles and engulf their prey from underneath. This foraging behavior is also called "bubble net feeding method". This algorithm is mainly used for the computation optimization and applicable to different graphs, trees and unstructured data. This algorithm is able to compute the maximum and minimum value of the function. WOA works on the user defined fixed variable and it address a large number of optimization problem. In the initial phase of the WOA design variables are randomly generated after the raining process. The best variables are selected on the basis of minimum cost function. The initial population of the optimization algorithm is in the form of matrix and dimension D.

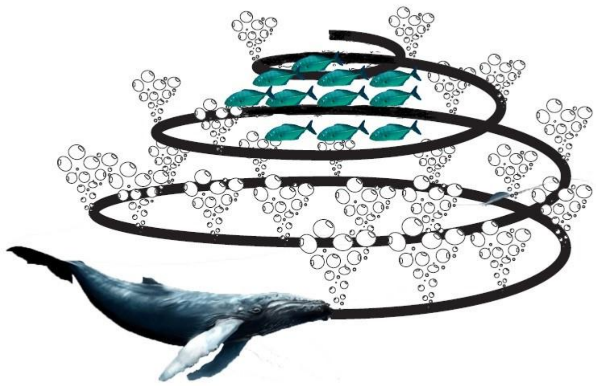

Figure 1.5: Bubble net caused by whale to surround prey

II) METHODOLOGY:

STEP 1: The standard whale optimization algorithm starts by setting the initial values of the population size n, the parameter a, coefficients A and C and the maximum no. of iterations.

STEP 2: Initialize the iteration counter t.

STEP 3: The initial population n is generated randomly and each search agent Xi in the population is evaluated by calculating its fitness function f(Xi).

STEP 4: Assign the best search agent X.

STEP 5: The following steps are repeated until the termination criterion is satisfied.

STEP 5.1: The iteration counter is increasing t = t+1.

STEP 5.2: All the parameters a, A, C , I and P are updated.

STEP 5.3: The exploration and exploitations are applied according to the values of p and |A|

STEP 6: The best search agent X is updated.

STEP 7: The overall process is repeated until termination criteria is satisfied.

STEP 8: Produce the best found search agent (solution) so far X.

2. PERFORMANCE

In this paper, we have compared performance of localization done by existing approach i.e PSO with localization done by present approach i.e WOA

Table 2.1 Mean squared error comparison in different anchor nodes

ANCHOR NODES	PSO	WOA
4	3.13299	3.13299
8	2.89935	1.93356
12	2.13566	1.32598
20	1.80007	1.00033

In table 2.1 analysis of number of anchor nodes and analysis on the existing approach Particle swarm optimization (PSO). The particle swarm optimization use routing the data by LEACH approach and then optimizes locally and globally. Its increases the overhead, doesn't converge efficiently and select random localization approach. This process improves by using hybrid optimization by whale optimization algorithm, thus converges the error and increase the accuracy of WSN node. Localization algorithm can be realized easily, but the localization accuracy is poor. KPS required deployment knowledge which is generally not available with sensor nodes. GPS-less low-cost outdoor localization also depend on communication range and separation of reference nodes and algorithm is fully distributed, but it only requires a relatively small number of communications and simple calculations and has good scalability and robustness.

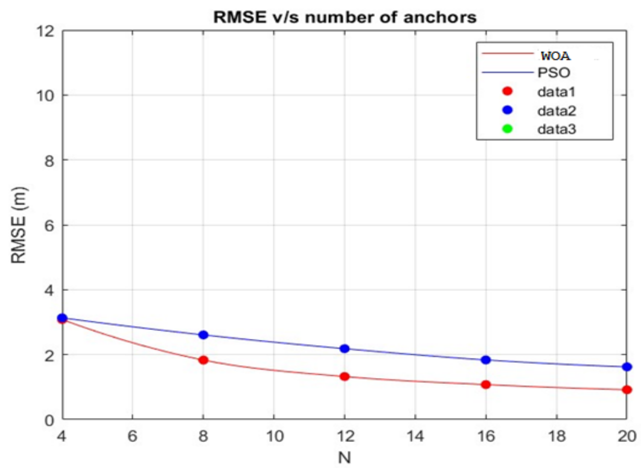

Figure 2.1 Comparison of mean squared error in different number of Anchor nodes

Fig 2.1 shows the analysis of Root Mean Square Error (RMSE) at different anchor nodes. Moreover, comparison between mean square errors between existing approach i.e PSO and whale optimization (WOA) is done. The graph clearly shows that the RMSE values obtain by WOA are smaller than PSO, thus increasing accuracy.

Table 2.2 Cumulative error comparison different distance

Distance[in m]	WOA	PSO
0	0.01	0.05
0.5	0.02	0.33
1	0.03	0.54
1.5	0.05	0.73
2	0.09	0.83
2.5	0.12	0.9
3	0.18	0.96
3.5	0.26	0.97
4	0.37	0.99
5	0.48	1

In table 2.2 analysis of cumulative error in proposed approach and existing approach according to distance increases but overall proposed approach increases the accuracy of localization of node but existing approach (PSO) doesn't increase it.

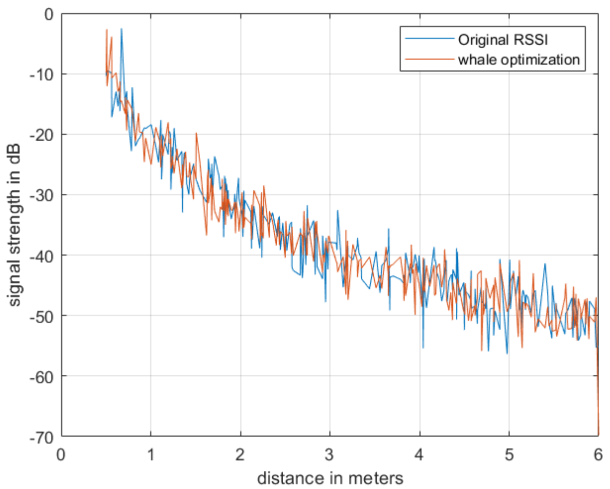

Figure 2.2 Comparison of proposed signal strength in different distance by WOA

In fig 2.2 there is analysis of prediction of signal strength for node localization. This process improves by using optimization by whale optimization algorithm. Clearly, the convergence in this graph is better than Fig 2.3 i.e convergence by PSO. More convergence means more accuracy, thus increasing accuracy.

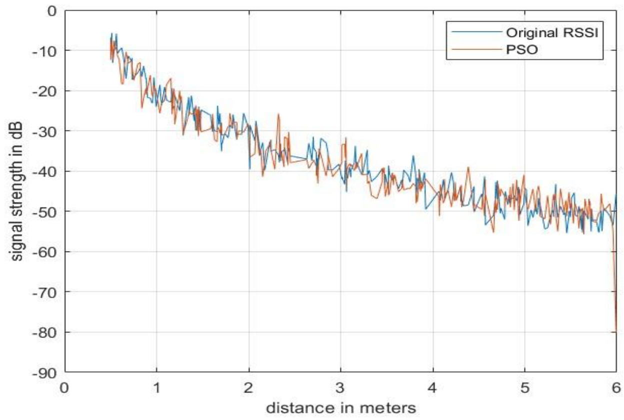

Figure 2.3 Comparison of existing signal strength in different distance by PSO

In fig 2.3 there is signal strength analysis of existing approach i.e Particle swarm optimization (PSO). The particle swarm optimization doesn't converge much as compared to WOA (in Fig 2.2) therefore less accurate.

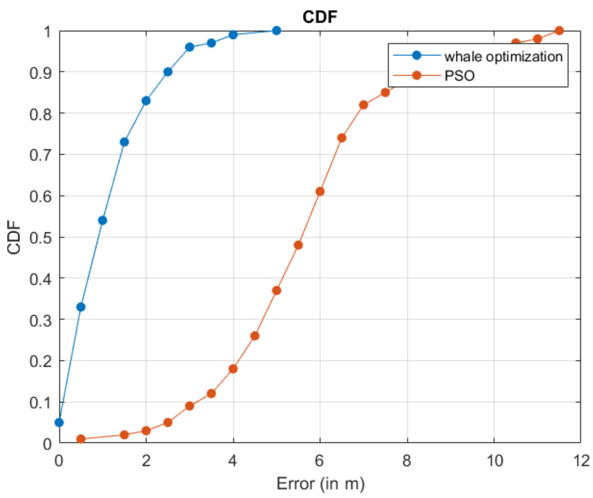

Figure 2.4 CCDF error according to distance of nodes

In fig 2.4 analysis of CCDF or cumulative which increases point to point but in comparison CCDF error in whale optimization (WOA) is clearly less than PSO approach.

3. CONCLUSIONS

The Optimal location of base station can be obtained such that either the transmission energy expenditure is minimum or lifetime of the sensor network is maximum. If all nodes suffer only free space transmission loss to base station, then centroid of nodes is the optimal position for base station deployment. If all nodes suffer only multipath transmission loss to base station then point is the optimal position for base station deployment. If some nodes suffer free space loss and remaining nodes, multipath loss to base station, then point O is the optimal position for base station deployment. This location cannot be calculated by any method. It can be guessed only for certain situations. We have suggested a method to find base station location quite closer to the optimal point. Our method can be used in any topology and has a better performance than existing approaches like PSO. In particle swarm optimization routing data is performed by LEACH approach, then optimization is done by using many function evaluations. It increases the overhead and doesn't converge efficiently. PSO fails in local search but WOA gives high local optima and works at high computational speeds due to need of less evaluation parameters. This process thus improves by using optimization using whale optimization algorithm, so converge the error and increases the accuracy of WSN node localization.

4. FUTURE SCOPE

Algorithms for placing more than one base station can be explored depending on communication parameters. More accurate methods can be developed for anchor free localization in Nano modules for identification of bottleneck nodes and resulting lifetime enhancement techniques. Further, we fed at the end of this study that overheads needed to implement any method should be as slow as possible and low enough to made it viable. Further if random access MAC (medium access control) is used, there will be random delay and energy overhead and cadette impact of these needs more investigations along with new methods to minimize this delay and to improve throughput per unit energy consumed. The combination of WOA with other approaches and using other fitness functions can be used in clustering problems. This algorithm can also be used for multi optimization problems

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