Hybrid Evolutionary Techniques for Ultra Wide Band Sensor Network Localization

M. Jamuna Rani, V. Geethalakshmi, K. Sindhumitha

Abstract--- Localization of sensors is an important and an integral issue for wireless sensor networks control and operation. Definite self-localization competence is immensely desirable in a wireless sensor network. A prominent complication in distance oriented localization of wireless sensor network is whether a given sensor network is cognizable or not. This paper introduces an innovative and computationally proficient localization method for WSN that uses Tabu Search (TS) based global optimization on the results of Hill Climbing based local optimization for the location computation and optimization of sensor nodes. From the performance analysis of this integrated method it is prominent that in spite of memory demands, TS-based method has superior convergence characteristics compared to other earlier proposed WSN localization techniques. Also, trends in the recent years have shifted to the hybrid optimization methods i.e. optimization by hybridization of metaheuristics and other techniques. This greatly reduces localization error and computation time for large networks. In the proposed system hill climbing local search method is implemented along with tabu search algorithm for efficient localization.

Keywords--- Localization, Tabu search, Hill climbing, Optimization, Meta-heuristics.

I. INTRODUCTION

A wireless network, which communicates using high-frequency radio waves rather than wires to is another option for networking. This option can be used to expand their existing wired network or to go entirely wireless. Wireless hence allows increased mobility but decreases range.

Smart environments epitomize the next transformative step in automation of transportation, utilities, home, transportation and industries. This smart environment relies primarily on the sensory data collected from the real time world. Sensory data comes from the various sensors distributed in different location with different modalities. The challenges in this field are enormous which include finding the required data, monitoring and compiling, computing and evaluating, and decision-making. The knowledge required by smart environments is provided by the WSNs, which are accountable for sensing and also for the preliminary stages of the processing group.

Sensor nodes are neighbourhood processing and wireless communication capable mini, cheap, low-powered and distributed devices. A single sensor node is capable of only a controlled level of processing but on coordination with the information from various other nodes, they are capable of measuring any specific physical environment with great detail. The main objective is to meet all the above mentioned features into a single chip.

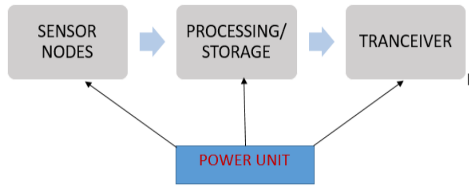

Figure 1: Structure of sensor nodes

II. RELATED WORKS

Localization in wireless Sensor Networks

Localization exists as the backbone of numerous emerging applications in Wireless Sensor Networks (WSNs) which include prominent fields such as military, Health services, environment monitoring, home and office automation, weather forecasting and so on. Majority of these applications require services based on location. In spite of GPS being an immediate solution to these problems, increased cost and power consumption as well as performance glitches have been the pre-requisite for the development on localization algorithms. Localization can be explained as the method of determining the position of remote nodes, either by using the information from the nodes with their positions known, or using the congruence information between the remote nodes. Localization techniques are broadly classified as follows:

- Sparse and Dense networks
- Anchor based and Anchor free networks
- Indoor and Outdoor networks
- Cooperative and Non- Cooperative networks
- Static and Mobile networks

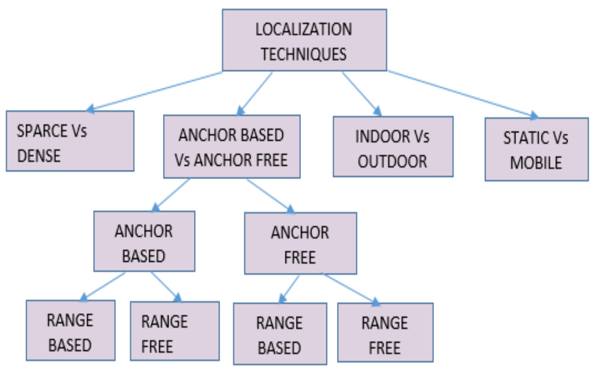

Figure 2: Classification of localization techniques

Manuscript received February 01, 2019
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This diverse classification of the localization techniques is made considering the size of the network and also it takes into account the specific application of the different types of algorithms as well as the mobility and usability of the beacon nodes. Thus one has to find an appropriate algorithm that full fills some special requirements and suits the demands.

Location Optimization

Optimization is a method of moulding a scheme, a problem or a system completely ideal, fool proof and as effective as possible. It can also be justified as finding a most cost effective alternative or otherwise obtaining the highest possible performance gain under specific conditions taking into concern the desired factors and leaving behind the undesired ones. The word optimum signifies "maximum" or "minimum" of certain factors based applications.

Some of the main optimization techniques include genetic algorithms, evolutionary strategies, evolutionary programming, and genetic programming and so on.

III. HYBRIDIZING HILL CLIMBING WITH TABU SEARCH ALGORITHM FOR LOCALIZATION OF SENSOR NETWORKS

This paper proposes an innovative approach which is based on initially applying Hill Climbing algorithm and then connecting it with a Meta- Heuristic algorithm known as Tabu Search optimization algorithm for efficient and optimised localization. The initialised nodes are distributed adversely in the suspect range wherein some nodes are considered as anchor nodes that is the location is known.

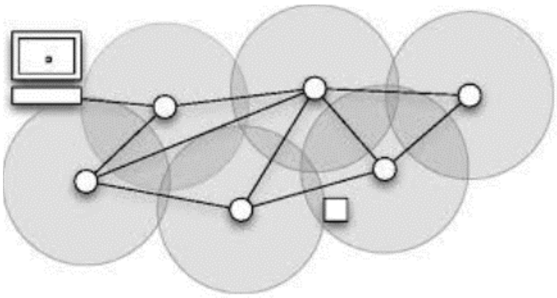

Figure 3: Anchor nodes movement in a network

The be a connotes shift randomly in the field space created by the simulator. As they drift randomly the anchor nodes update their location regularly through the beacon packets at fixed intervals to all the other un-localised nodes. The beacon packet is telecasted by anchor node. The beacon nodes drift around the field space with constant speed and are updated for every 10 seconds. The other sensor nodes in the field create the visitant list from the location information obtained from the beacon packets. It assembles the required information from the beacon packets for determining its position. After assembling the initial and final packets in the visitant list are favoured. These are taken as the two edge points of that particular node connectivity. These points are taken as the centre points and correspondingly two circles are drawn. They are considered as the sensor node's two possible locations.

Block Diagram

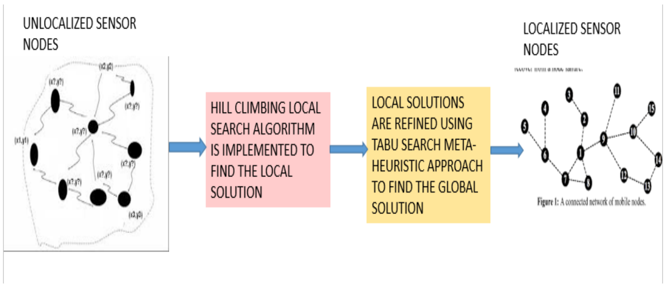

Figure 4: Block diagram of the proposed scheme

Above figure shows the proposed localization process, which initially uses a local search optimization technique called Hill Climbing (HC). This algorithm is known for searching a better solution in the local area that is the neighbourhood. The theme of HC is to find a better state than the existing one there by refining the solution. Then the Tabu Search Algorithm takes the results of hill climbing as its input to the final optimization process. The possible solutions of a node derived by hill climbing algorithm is stacked in a Tabu list and a final optimized solution is derived from this.

Hill Climbing Algorithm

Hill Climbing is an iterative local search optimization technique that finds a better solution by beginning with an arbitrary solution by making incremental changes. These incremental changes are continued until no better solution can be found. Hill climbing is often the most preferred algorithm than other such procedures when constrains such as limited time and real time applications are involved where in small number of iterations produces a considerably effective solution. Hill climbing is also called an all-time algorithm as it has the capability of yielding a good solution at any time even before it ends due to interruptions.

Tabu Search Algorithm

The Tabu Search algorithm is a connectional optimization which is an efficient global search technique that utilizes the method of recognition to carry out the search by biding away from local optima and averting the cycles. The actual temperament of the TS lies in using its tractable and flexible memory in an organised way that keeps track of the previously visited solutions whereas the other techniques only store the objective function and not the solutions visited so far.

The sensor nodes perform the following operations in the Tabu search localization scheme:

1. Construction of the visitant list also called as the tabu list, it is created by using the first estimate as its initial entry.
2. Formation of neighbourhood set. The initial estimate of the solution is given a disturbance which moves it to a new value. Although any number of random perturbations is allowed, here they are restricted to four movements that take the initial estimate (xc, yc) to the neighbours (xc ± Δx, yc ± Δy).

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The objective functions at these neighbours are evaluated.

3. Updating the solution and tabu list. The current solution is moved to the best available non-tabu neighbour even if it deteriorates the present objective function value and the tabu list is updated.
4. Steps 2 and 3 are repeated until the objective function value falls below a predefined threshold value or the number of iterations crosses its threshold value.

IV. RESULT AND ANALYSIS

Comparison of hill climbing and hill climbing integrated with Tabu search accuracy levels

The root mean square error (RSME) of the sensor nodes using x and y coordinates from the position obtained and the actual position was calculated in meters and a total of 100 localized nodes is taken into consideration.

Table 1: RMSE with and without tabu search

NO. OF NODES	HILL CLIMBING	HILLCLIMBING WITH TABU SEARCH
10	520.77 m	130.05 m
20	630.70 m	174.84 m
30	587.75 m	181.17 m
40	578.72 m	140.82 m
50	600.89 m	183.49 m
60	596.02 m	199.83 m
70	553.74 m	140.04 m

Execution time analysis

Approximately 95% of the nodes acquired localization within 500 seconds of simulation time. But most probably the same localization percentage was obtained on increasing the simulation time because of the substantial amount of time that is required to visit all the nodes in the field space. The results are shown in the following Table:

Table 2: Execution time of varying network size

SIMULATION TIME	NO. OF LOCALISED SENSOR NODES
100 s	95
200 s	97
300 s	97
400 s	97
500 s	97

Execution of Tabu search

The performance of the proposed algorithm is evaluated by performing various simulations were using MATLAB. A sensor network which comprises of 50 to 200 randomly and scarcely distributed nodes is initialized in the field space. All the nodes are present within the boundary at random coordinates. The anchor nodes are used in the telecast and cost function. The simulated results are shown in the figures 5, 6 and 7 given below:

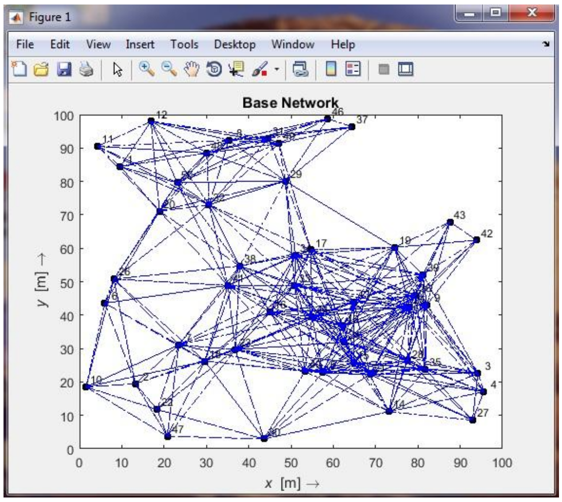

Figure 5: Base network with localization

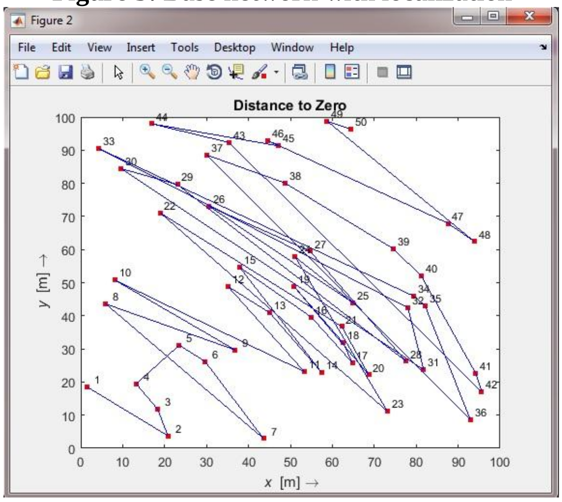

Figure 6: Distance measurement

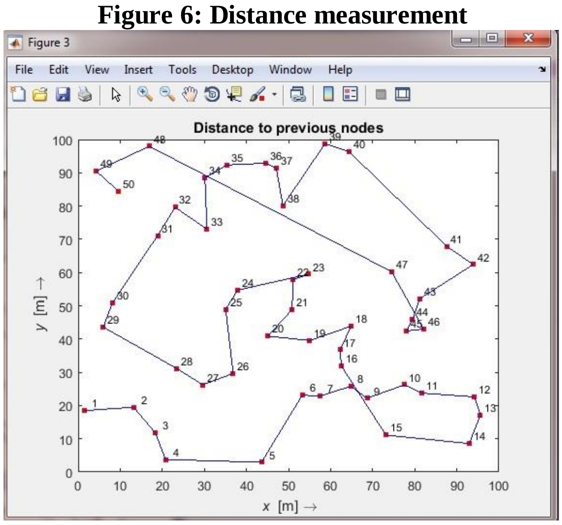

Figure 7: Network construction with Tabu search method.

V. CONCLUSION

Localization based on mobile anchors does not complicate the usage of any hardware by using range-free localization methods.

As a result of this experimentation it is seen that the number of localized nodes is comparatively high compared to the other existing techniques which proves that this technique of Hill Climbing is effective for localization purpose within the neighbourhood which provides the optimum local maxima. However, it does not provide the required level of accuracy in localization. Therefore, Tabu-search algorithm a Meta-Heuristic optimization method is applied to the results of Hill Climbing. This proves to be an effective way in reducing the simulation time thereby increase the accuracy of localization with better convergence thereby reducing the localization error. Thus, from the above results ultimately the localization error is reduced while using Hill Climbing with Tabu search when compared to other standard techniques. The future work include exploiting other combinations of hybrid localization methods and further improve the localization parameters.

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