Power Efficient Localization schema for Wireless Sensor Network

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ABSTRACT

This paper examines localization error will be minimal after adjusting the radio range of beacons' and error performance tradeoffs. Anchor based-range-free schema for Wireless Sensor Network. Localization algorithms are different in different network environments. My work is to find out an efficient localization algorithm for wireless sensor network. The idea is to use anchor nodes for localization. Anchor nodes are special nodes that know their physical location. Anchor nodes are connected to GPS to find out their location. Wireless sensor nodes that do not know their location are known as unknown nodes. Unknown nodes communicate with anchor nodes. Anchor nodes use beacons and broadcast it within the range and make the proximity. The beacons have the information of anchor node as follows: Anchor's ID, Anchor's absolute coordinate, Anchor's power level. Its estimated maximum distance that beacon can travel.

Keywords- WSN, GPS.

1. INTRODUCTION

Now days, advances in miniaturization, Wireless Sensor Networks have become very famous in different applications in the present life. These are benefited for control and monitoring like, target tracking, civil and military applications, disaster management, habitat monitoring, climate control etc. A wireless sensor node can be built easily using small electronic cheap technology. Wireless sensor networks (WSN) hold a promise to "dwarf previous revolutions in the information revolution". WSN are envisioned to consist of hundreds to thousands of sensor nodes communicating over a wireless channel, performing distributed sensing and collaborative data processing tasks for a variety of vital military and civilian applications.

2. RELATED WORK

Connectivity-based Multi-hop localization algorithm

In this paper, non-anchor nodes are not essentially one hop neighbors to anchor nodes. Here we don't need any measurement techniques like RSSI, AOA etc. but generally uses connectivity information, i.e." who is within the communication range of whom".[1] to calculate the location of sensor nodes. Here we have focused idealized model that makes two assumptions:

- Perfect spherical radio propagation
- Identical transmission range (power) for all radios.

Various nodes in deployed with overlapping areas of coverage termed as reference points (labeled R_1 to R_n). Let's assume these anchors are placed at defined positions, (X_1, Y_1)–(X_n, Y_n), this formed a regular mesh type structure and broadcasts its beacon at regular time period (period = T) having their relevant positions. Here a certain assumption is followed that neighboring reference points might be coordinated in order that their beacon signal transmissions may not overlap in time. In addition to that, in any time period T, each reference node would have broadcasted exactly one beacon signal [3].

Each sensor node snoops for a given time period t and assembles all the beacon signals it gets from different reference points. In this paper, Bulusu *et al.* defined the information per reference node R_i by a *connectivity* metric (CM_i), that is:

$$CMi = \frac{N\ recv(i,t)}{Nsent(i,t)} \times 100$$

For reliability in presence of various environmental vagaries, we have to configure our connectivity metric with a sample of S, where S is the sample size that tuned with total sending beacons (i.e., $N_{sent}(i, t) = S$). Further we have to configure T to be the time interval between two consecutive beacon signal transmissions, we set t, the receiver's sampling time[3] as:

$$t = (S + 1 - e)T \quad (0 < e \ll 1)$$

When sensor nodes receive the beacons, then node make a proximity to the reference points and we have to set our connectivity metric, CM_{thresh} (lets 90 percent). The receiver computes itself to the area with the intersection of the connectivity areas of this set of anchor nodes, that is named as the *centroid* of these reference points: So we use multitrilateration property to find node location.

$$(Xest, Yest) = \left(\frac{Xi1 + \cdots + Xik}{K}, \frac{Yi1 + \cdots + Yik}{K}\right)$$

But the accuracy depends on how far estimated location is to actual location, so we have to compute localization error. Localization error (LE) is defined as:

$$LE = \sqrt{(Xest - Xa)^2 + (Yest - Ya)^2}$$

Hence, to make a better result we should use more reference nodes to become localization area finer, and we should deploy nodes on grid to fine the covered localization area. Ultimately the ratio(R/d) must be increase to perform better result so that the localization error might be minimized.

3. TESTING METHODOLOGY AND SIMULATION RESULTS

Before starting the work, I want to discuss two assumptions for idealized model before working on Centroid algorithm that is based on range free localization procedure.

1- Radio propagation will be perfect spherical.
2- All sensor nodes will have identical radio range.

As we know in centroid method, we have to deploy anchor nodes or reference nodes within applied field where unknown nodes deploy randomly in the specified coverage field.

3.1 Deployment of anchor nodes

Here we start two types of deployment of anchor nodes:

- Grid based deployment
- Random deployment

3.1.1 Grid based deployment

We developed a framework for deployment of reference nodes within the area in MATLAB environment at 90m x 90m square region. In this working region, I used grid with various sizes for deployment of anchors on the points of grids. After taking anchors at grid points, we deployed sensor nodes randomly within that square region. Here we collect various samples and results by simulations. We deploy anchor nodes on grid points and take result with changing anchor's communication range or proximity range. After that we change grid size and further repeat same procedure. A detail outlook is represented here:

Testing at 10mx10m Grid size:

Here we select 10mx10m square grids within 100mx100m square region scenario. Then we set first anchor nodes communication range at 5m and deploy sensor nodes randomly at square area of 90mx90m.

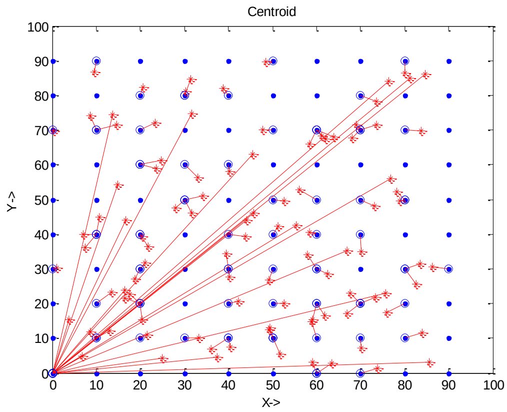


Fig 3.1 (A representation of 10m^2 grid size but radio range is only 5m of anchor)

- • Anchor grid-point node's position
- * Unknown sensor node's Position
- O Estimated location
- ----- Maximum error

There are possibly many non-anchor nodes which are not within the radio range of anchor nodes properly. So overall localization suffers and those node which are insufficient to fulfill the condition of centroid, could not find its proper location. These node's locations are placed at centre of axis in our simulation as a maximum error. We also simulated and calculated location error per node as well as the mean localization error.

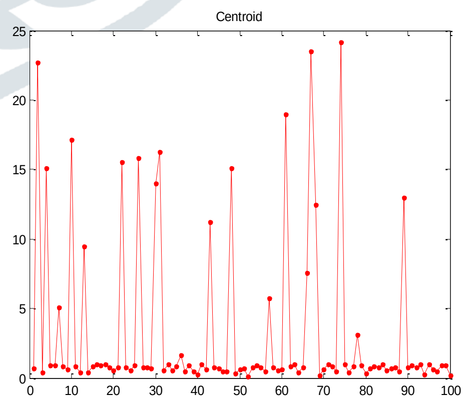


Fig 3.2 Error variation per node within network at 5m range of beacon

Here errors are shown correspondingly for every non anchor nodes. The peaks are showing the localization errors. This is because the whole region is not fully covered. In this case the mean localization error is 3.2278, and maximum error is 24.54, which is undesirable. Due to above insufficient coverage, more erroneous result we found because for any wireless sensor network to operate successfully, the active/anchor/reference nodes must preserve both sensing coverage and network connectivity. Now we increased the range equal to grid size and then find something interesting results.

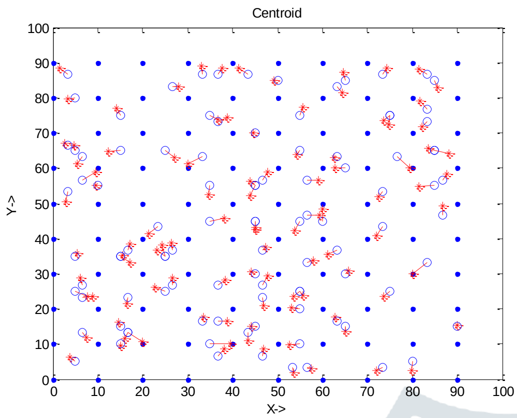


Fig 3.3 Simulation result at 10m range

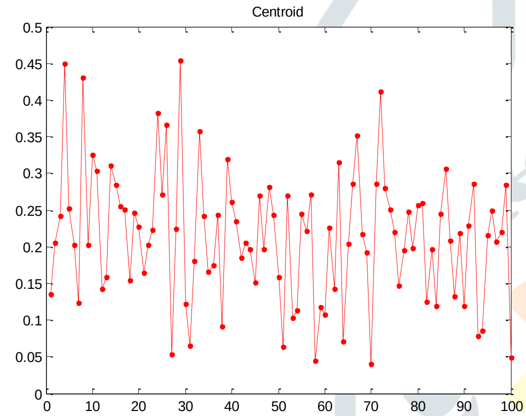


Fig 3.4 Error variation per node within network at 10m range of beacon

Now we saw here satisfactory results at range of 10 m of anchor point. And maximum/minimum and mean localization error reduced up to a great extent. Let's set its range at R=15 then we get the following results

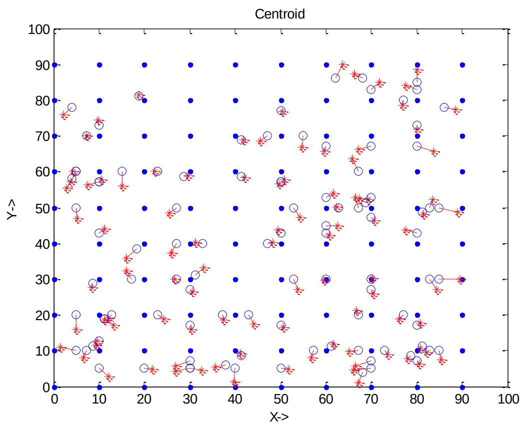


Fig 3.5 Simulation result at 15m range

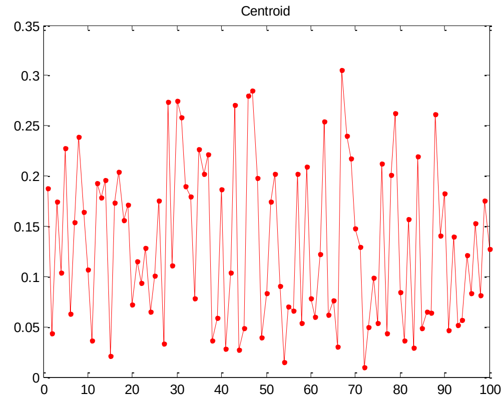
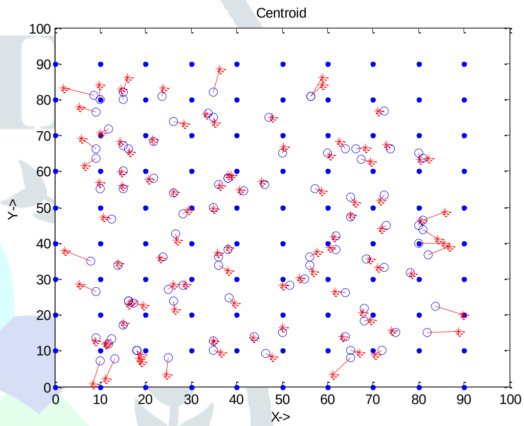


Fig 3.6 Error variation per node within network at 15m range of beacon

If we further increase the range we will get something progressive result.



Now we test at R=20m and get result as shown in figure 3.7

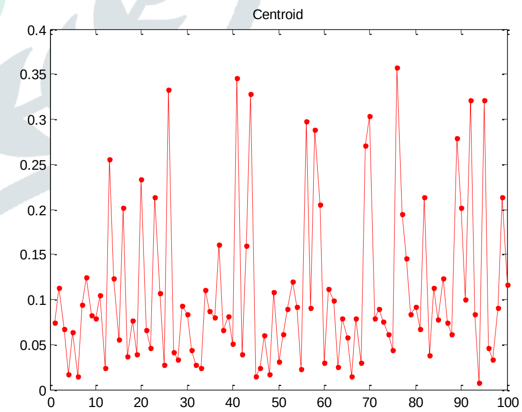


Fig 3.8 Error variation per node within network at 20m range of beacon

Here we got the result which is more accurate as compare than previous. Here we can see sharp errors at the edges near to borders. This is the reason of irregularity of proximity anchor nodes at the boarder sides. This is due to involving more number of anchors as the neighbors to non-anchor nodes, just because of high range of anchor nodes proximity takes more number of candidate nodes.

Now if we further increase the range of nodes then this irregularity will be increasing because centroid will shift towards denser anchor nodes in nature

So here we see that as range increases localization error also increases due irregularity of proximity of anchors.

Now we take many samples at different ranges in 10x 10 grid size and make a graphical representation between mean localization error and radio range of anchor nodes in table 3.1

Table 3.1

After getting the error graph between range of beacon and mean localization error, we find that error reaches minimum between 10 m to 20 m ranges of beacon and further increase of range error statically increasing. So this is an important note that being grid size 10m, the error falls minimal from 10m to 20m range of beacon.

Now before reaching any conclusion we should further test on various grid sizes so that result must be testified.

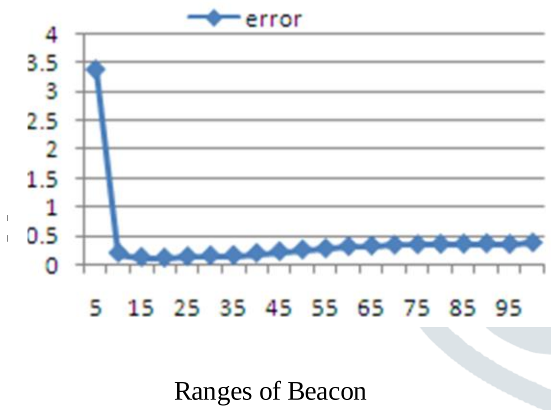


Fig.3.9 A graph between range of beacon and mean localization error

Testing at 20m x20m grid size:

When we simulate in MATLAB with grid size 20m^2 having 100 anchor and 100 testing nodes within the 90m x90m working region then various results we get.

Range of Anchor	10	15	20	25	30
Mean localization error	2.033	0.2959	0.2053	0.1320	0.1264

Table 3.2

the actual graph between ranges of beacon and mean localization error we further may reach on the conclusion that between 20m to 40m error deflection is minimal. So in case of grid size 20m the error is minimal between 20m to 40 m. But before reaching at any conclusion we should further test once again at different grid size to testify that result.

3.1.2 Random Deployment strategy:

If we deploy the optimal anchor nodes to achieve good quality of localization, yet there will be such borders areas where the non-anchor nodes will strive for regular geometry to overcome the closed proximity neighbor in adequate quantity. So more nodes falling at the edges of sensing field will overall make poor localization. In figure 4.1 it is shown that at edges localization error is greater.

Range of Anchor	5	10	15	20	25
Mean localization error	3.2278	0.2151	0.1330	0.1096	0.1399

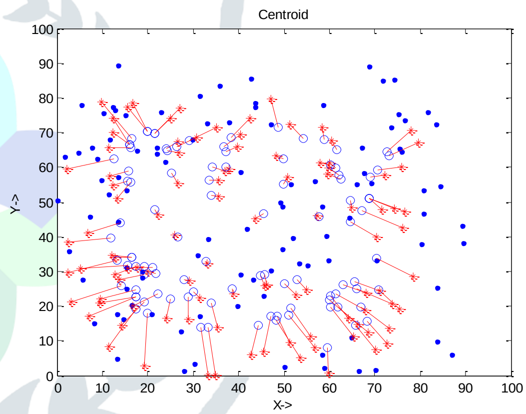


Fig4.1 Random deployment of anchor nodes in 90x90 and testing nodes Within 80x80 working field.

In old deployment the anchor nodes and non-anchor nodes are applied same working areas in 90m x90m working region. But if we confine the sensing region for testing nodes over keeping anchor node region same, then its beneficial and applicable to reduce the localization error up to some extent. So if we deploy testing nodes within 80m x80m working region with keeping anchor nodes in 90m x90m working region then the scenario will be totally changed and the testing nodes which were falling at edges now will be covered with some extent with anchor sensing field. So localization error of sensor network might be reduced up to desirable level.

Here we test with 100 anchor and 100 testing nodes within 90m x90m working area in first condition. Now we apply same centroid algorithm with changing radio ranges of reference nodes and take many samples. We get the mean localization error with accordingly different radio ranges of anchor points. These samples are

Range of anchor	10	15	20	25	30	35
Mean localization error	0.606	0.303	0.276	0.257	0.267	0.305

shown in table 4.1.

Table 4.1

4. CONCLUSIONS & FUTURE WORK

This paper introduces and discusses wireless sensor networks and localization concepts. we took many snapshots at different ranges from 15m to 100m ranges and here also find that firstly localization error degrades rapidly and remain minimum level between 30m to 60m.Now if we generalize these facts as we have seen previous results among grid with sizes 10 m^2, $20m^2$ and $30m^2$, suppose the length of edge of any square grid is X, then the localization error will be minimal after adjusting the radio range of beacons such that:

X< range of beacon< 2X

This inequality relationship is evaluated by the various samples with changing gird sizes and accordingly ranges of anchor radio transmitter.
In random deployment scheme, we shorten the testing node deployment working area but keeping anchor node deploying area normal.

$$\boldsymbol{Reduction\ of\ error}(\%) = \frac{\sum(\boldsymbol{MLE1} - \boldsymbol{MLE2})}{\boldsymbol{total\ no\ of\ range}}$$

Where MLE =Mean localization error

After applying the same procedure we find that 5% error is reduced. So if we compare it with other algorithm, the smart feature of the connectivity-based localization scheme is their simplicity. In my future work to comprises deploying localization method to noisy environments.

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