Enhanced Centroid Localization of Wireless Sensor Nodes using Linear and Neighbor Weighting Mechanisms

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ABSTRACT

The drop in cost and reduction in size of sensor nodes has eased the development of wireless sensor networks (WSNs) applications. However, the noise and disturbing nature of most sensing environments require accurate algorithms that can overcome these difficulties. Nodes' localization is one of the basic activity a WSN can perform to make other network's functionalities, such as routing easy to tackle. Nowadays there exists many localization methods, however many pose computational and/or accuracy issues. Centroid is a localization algorithm by which an unknown node's coordinates are estimated as the centroid of anchors' coordinates. Its implementation is simple but it has a high error rate. In this paper, two methods are proposed to enhance the centroid localization algorithm. The first, Linear Weighting Centroid (LWC) uses the distance between the anchor and the unknown nodes to linearly weight each anchor's coordinates. The second, the Neighbor Weighting Centroid (NWC) uses the number of intersect nodes between an unknown node and its neighbor anchors to estimate the degree of proximity of the anchor nodes. Both methods assign larger weights to closer anchors and lesser weights to remote anchors to improve centroid accuracy while keeping computation almost at the same level. Simulation is used to study the performance of both mechanisms. The results show that for a large WSN, both methods localize unknown nodes with better position accuracy than centroid, with LWC performing better than NWC.

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wireless sensor networks, localization, centroid, weight.

1. INTRODUCTION

The rapid developments in sensor hardware design in recent years have spurred the deployment of a large number of Wireless Sensor Networks (WSNs) used in various application areas, such as home, health, surveillance and industry [1]-[3]. WSNs are for example used in industry to detect abnormal events such as high pressure or temperature so as to prevent their occurrences or to gather important data that when analysed can help in monitoring the production process or the health of machines [4]. However, in most of these applications sensor nodes are connected using wireless technologies rather than wirelines. Adopting wireless technology presents great advantages over traditional wire systems since it provides better mobility, low cost infrastructure and is easy to maintain and upgrade [5]-[8]. Wireless technology is also easy to deploy in unpleasant and inaccessible environments.

Many applications of WSNs require a large population of tiny and low-power consumption sensor nodes to cover the field of interest, with each sensor node consisting of a micro-controller whose function is to perform multiple tasks such as processing of signals, managing the power consumption, collecting data and communicating the data to the task manager through multi-hop [8] [9].

However, the use of WSNs is still hampered by several issues such as coverage [1] and node's localization [10]. Node's localization is important since it is relevant to many applications which depend on knowing the coordinates of sensor nodes. For a manufacturing factory for example, the task manager, may deploy sensor nodes near the machines to control their state. In this case, sensor nodes are also equipped with actuators, so that they can perform both types of actions: on one hand, various parameters such as pressure or temperature are gathered and, on the other hand, some control operations are performed on the machines to maintain or protect their health. The described system requires that the location of each node is known, it is irrelevant to know that a node in the system has measured a high temperature, if the information about where the problem occurs is unknown.

The past decade has seen a number of algorithms to provide location of the nodes [11]-[13]. A large number of these algorithms assume that the sensor network consists of a small number of nodes with known positions called anchor nodes. The locations of anchors are determined either using Global Positioning System (GPS) or a manual configuration process [14]. The other nodes, called unknown nodes, have their locations unknown and rely on the anchor nodes to locate themselves.

Generally, localization algorithms are grouped into two classes depending on the information used to locate the node: range-based [15] [16] and range-free [17] [18] localization methods. In Range-based techniques special hadware are used to measure the absolute distance between an anchor and unknown node, and then estimate the unknown node location. However, the accuracy of such a measurement is subject to many factors such as the environment noise. In addition, the use of specialized hardware makes the design of sensor nodes complex and therefore increases the associated cost [19]. Range-free algorithms, on the other hand, are very attractive for WSNs because they rely on the estimated distance between nodes, and as such, the design of sensor nodes' hardware is simplified [19].

Anchor nodes are also commonly used in range-free localization methods. In [17] for example, a simple Centroid Localization (CL) method is introduced to compute the location of a node by averaging the locations of several neighbor anchor nodes. Localization using centroid is attractive as it is simple, easy to implement and require less computation. However a simple average of neighbor anchors' locations leads to high localization error. The Weighted Centroid Localization (WCL) [20] was proposed later to improve CL accuracy. WCL uses the distance and a static degree-factor, that indicates the degree to which a distant anchor contributes in the determination of a node location. The degree-factor in WCL is set such that the weight increases as the distance between the anchor and the node to locate decreases.

In this paper two localization algorithms are proposed to improve centroid accuracy: the Linear Weighting Centroid (LWC) and Neighbor Weighting Centroid (NWC) algorithms. Both algorithms can be used to improve the localization accuracy of sensor nodes while keeping computation simple. In LWC, an unknown node first finds neighbor anchor nodes to which it is connected, and estimates the absolute distance between itself and its neighboring anchors. Then, a greater weight is assigned to the anchor which has the shorter distance to the node. Anchors with larger distance values are assigned lesser weights as they are assumed to be farther from the node. In LWC, a weight is assigned such that its value decreases linearly as the distance from the anchor to the node increases.

The NWC algorithm is derived from WCL; however, the degree-factor used in the computation of the the weights is set dynamically using the number of common neighboring nodes between an anchor and the node to be located. NWC algorithm is built using the following assumption: the closer an anchor is to the node, the higher the number of neighboring nodes they have in common. NWC assigns larger weights to anchors with higher numbers of common neighbor nodes; and lesser weights to anchors with fewer numbers of common neighbor nodes.

After computing the weights, both algorithms use the weighted localization centroid to localize the node. The performance of the proposed localization algorithms are evaluated using simulation and the results show that both algorithms achieve a better result than the classical centroid, with LWC realizing localization with higher accuracy than NWC.

The rest of this paper is organized in five sections. Section II briefly reviews some of existing works in sensor node localization. Section III discusses the centroid and weighted centroid localization algorithms on which we built our proposed algorithms. Section IV describes the proposed linear and neighbor weighted localization algorithms. In Section V simulations are used to study the performance of the proposed algorithms, while Section VI concludes the paper.

2. RELATED WORK

There are various approaches to node localization in wireless sensor networks. In the context of this research we consider the anchor-based approach where the presence of special sensor nodes called anchors, that know their locations, is required in contrast to free-based algorithms which do not assume the availability of anchor nodes [14]. In anchor-based techniques, unknown nodes rely on information provided by anchors to determine their coordinates.

Anchor based algorithms are also classified into range-based and range-free depending on whether the information provided respectively contains the absolute measured distance between nodes or not. The former measures the absolute distance and then use it to localize unknown nodes while the later uses an estimation of the absolute distance to localize nodes [18].

Time Of Arrival (TOA) [21] and Angle Of Arrival (AOA) [15] are examples of anchor based algorithms using range-based techniques. Range-based techniques rely on the absolute distance to compute the location of a node. In most cases, specialized hardware are used to obtain the absolute distance between nodes. For this reason, range-based methods are said to be expensive and not advisable in large scale WSNs. Today, range-free techniques are becoming more and more popular. Most of them use RSSI since it does not require additional hardware and is easy to implement. RSSI is then translated into the estimate distance using either theoritical or empirical techniques [15]. Some examples of range-free algorithms are DV-hop [18], Amorphous [22], Approximate Point in Triangle Test (APIT) [23] and Centroid [17].

DV-HOP is a method in which anchors flood packets containing their locations throughout the network. Flooded packets also contain a field that stores the number of hops along the way. In this way the hop-count distance between anchors and anchors, and between anchors and unknown nodes is determined. The hop-count distance values are then used to compute the average hop-count distance which is then broad-casted throughout the network. Unknown nodes then compute their location based on known coordinates of anchors, the hop-count distance, and the average hop-count distance. Similar to DV-Hop is the Amorphous algorithm which assumes prior knowledge of the density of the network and uses estimations of the off-line hop-count distances. Amorphous improves location estimation by using local information exchanged by neighbor nodes. APIT estimates the unknown coordinates of a node only if the node lies inside a triangle composed by three anchor nodes. The localization process is conducted in such a way that each sensor node uses a combination of audible anchor nodes to detect the smallest triangle in which it is located, and then estimates its location as the centroid of this triangle.

Centroid was introduced in [17], and estimates the unknown node coordinates from averaging the coordinates of all its neighbor anchor nodes. Weighted centroid localization, was later proposed in [20] to improve centroid accuracy. In weighted centroid, anchors are assigned weights inversely proportional to their distances to the unknown node; and location is estimated using the weighted average formula.

3. CENTROID LOCALIZATION

This section outlines the two centroid localization approaches upon which our algorithms are based. Centroid uses beacons sent out by the anchor nodes containing their location information (x_i, y_i). Upon reception of the beacons, the coordinates $(\hat{x}, \hat{y})$ of the unknown nodes are estimated as the centroid of the anchors'coordinates from which it receives the beacons, using the following formula:

$$\left(\hat{x} = \frac{\sum_{i=1}^{m} x_i}{m}, \hat{y} = \frac{\sum_{i=1}^{m} y_i}{m}\right) \tag{1}$$

where m represents the numbers of anchors that are within the coverage area of the unknown node. These anchors are also called neighbor anchors of the unknown node.

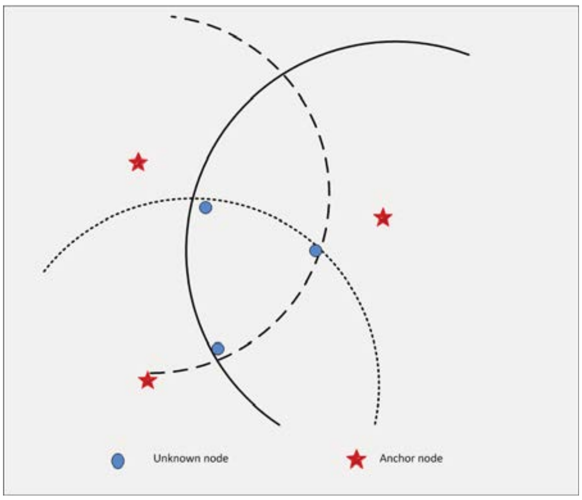


Figure 1: WSN with three anchor nodes and three unknown nodes.

If we consider the WSN in Fig 1, all the three unknown nodes which are situated within the intersecting region of the three anchor nodes will estimate their location position at one single point, the centroid of the three anchor nodes, regardless of their exact position. This is because centroid localization algorithm will assume that the three anchor nodes are located within an equal distance of each of the unknown node; this may lead to high localization error.

In [20] a more general and realistic case whereby some anchors are more likely than others closer to the unknown node is considered. They proposed a weighted centroid localization approach that improves the original centroid localization accuracy, by assigning larger weight to anchors that are considered closer to the unknown node and lesser weights to distant anchors. Hence, Equation (1) is generalized to the WCL formula given in Equation (2) for node localization

$$\left(\hat{x} = \frac{\sum_{i=1}^{m} w_i \times x_i}{\sum_{i=1}^{m} w_i}, \hat{y} = \frac{\sum_{i=1}^{m} w_i \times y_i}{\sum_{i=1}^{m} w_i}\right) \tag{2}$$

with $w_i = \frac{1}{(d_i)^g}$, d_i the known distance between the node to be localized and the anchor at position (x_i, y_i), and g a static degree-factor that indicates the degree to which the distant anchors contribute in the determination of the unknown node location.

The value of g has a direct impact on WCL performance, for example a very high value will approximate the unknown node closer to the closest anchor and increase the localization error. In [20] the authors suggested to conduct intensive analysis of the sensor nodes' transmission ranges and the dimensions of the network before starting with the localization process; and select a value of g that minimizes the localization error.

The centroid localization (CL or WLC) methods are simple and easy to implement. However, if the number of anchor nodes is low, they may lead to high localization error.

4. LINEAR AND NEIGHBOR WEIGHTING CENTROID

In our analysis, we view a wireless sensor network as a set of η nodes, consisting of η_s sensor nodes and $\eta_a (< \eta_s)$ anchor nodes, such that, $\eta = \eta_s + \eta_a$. The positions of the sensor nodes are unknown, whereas the positions of the anchors are known.

4.1 Linear Weighting Centroid

The proposed linear weighting centroid estimates the unknown location of the sensor nodes using the location of anchor nodes and their estimated distances to the unknown nodes. The distance is estimated as in [26], that is, using the RSSI and, we consider that two nodes can communicate if the RSSI between the two nodes is measurable. RSSI measurements depend on the distance between communicating nodes and the path-loss model used [26]. Depending on the path-loss model, the RSSI P_{ij} for the signal emitted from sensor node j to anchor i or vice-versa is formulated as

$$P_{ij} = P_0 - 10\theta log_{10} d_{ij} - \nu_{ij} \quad [dbm] \tag{3}$$

for $1 \leq i \leq \eta_a$ and $1 \leq j \leq \eta_s$, where P_0 is the RSSI computed at 1m distance, d_{ij} the distance between sensor node $j(d_{ij} \geq 1m)$ and anchor i, and parameters θ and ν_{ij} respectively the path-loss exponent and random variables representing the log-normal shadow fading [26].

Given P_{ij} in Equation (3), the estimated distance between the two communicating nodes i and j is derived as follows.

$$d_{ij} = 10^{(P_0 - P_{ij})/(10\theta)} \quad [m] \tag{4}$$

The estimated distance d_{ij} in Equation (4) is then used in LWC algorithm to compute the weight w_i associated with anchor i. The weights in LWC decrease as the distances from the anchors to the unknown node increase. Fig. 2 summarizes the LWC mechanism. When a node j has established wireless connections with a number of neighboring anchor nodes $(i, i < \eta_a)$, it uses the RSSI to estimate its distance d_{ij} from each anchor node i. The value of d_{ij} âĂŇis then compared with the two threshold values: the minimum distance value d_{min} and the maximum distance value d_{max} to determine the weight associated to the anchor's coordinates. If the distance is equal to the minimum distance value d_{min}, then the anchor is assigned the largest weight $(\alpha + \beta)$ as it is considered to be the closest to the unknown node. Otherwise the weight decreases linearly as the distance increases, as shown in Equation (5)

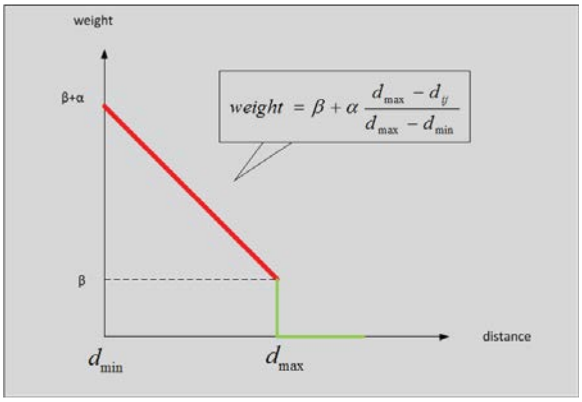


Figure 2: Linear weight of anchors' coordinates in WSN

$$w_i = \alpha \frac{d_{max} - d_{ij}}{d_{max} - d_{min}} + \beta \tag{5}$$

where α and β are constants values. β represents the lowest value of the weights and is introduced to ensure that the farthest neighbor anchor is not excluded in the determination of the unknown node location.

Equation (2) of WCL is expanded using the LWC weighting, resulting in the Equations (6) and (7) for node location .

$$\hat{x} = \frac{\sum_{i=1}^{m} (\alpha r + \beta r_i) \times x_i}{m\alpha r + \beta \sum_{i=1}^{m} r_i} \tag{6}$$

$$\hat{y} = \frac{\sum_{i=1}^{m} (\alpha r + \beta r_i) \times y_i}{m\alpha r + \beta \sum_{i=1}^{m} r_i} \tag{7}$$

where $r = d_{max} - d_{min}$ and $r_i = d_{max} - d_{ij}$.

A larger distance than the maximum distance d_{max} corresponds to an anchor node that is out of the coverage range of the unknown node. Such an anchor is naturally excluded in the localization estimation by setting the weight associated to its coordinates to zero. The weights in LWC are defined such that shorter distances have higher weights while larger distances have smaller weights. Thus, the weight and the distance between anchor and unknown node are inversely proportional.

The algorithm in Fig. 3 depicts one way to implement the linear weighting localization algorithm. It should be noted that when $d_{max} = d_{min}$, all neighbor anchors are within an equal distance of the unknown node, when such a situation occurs, LWC reverts to centroid localization algorithm.

while unknown node $i == true$ **do**
  Step 1: Poll neighbor nodes j and compute distance $d_{ij} \leftarrow 10^{(P_0 - P_{ij})/(10\theta)}$
  Step 2: for all neighbor anchors of i, compute
  $d_{max} \leftarrow max\{d_{ij}\}$
  $d_{min} \leftarrow min\{d_{ij}\}$
  $range \leftarrow d_{max} - d_{min}$
  Step 3: for all neighbor anchors of j, extract their (x_j, y_j) coordinates and do
  if $range \neq 0$ **then**
    $w_j \leftarrow \alpha + \beta \times \frac{d_{max} - d_{ij}}{range}$
    $(\hat{x}, \hat{y}) \leftarrow \left(\frac{\sum_{j=1}^{m} w_j \times x_j}{\sum_{j=1}^{m} w_j}, \frac{\sum_{j=1}^{m} w_j \times y_j}{\sum_{j=1}^{m} w_j} \right)$.
    return $(\hat{x}, \hat{y})$\{The location estimation is $(\hat{x}, \hat{y})$\}
  else $\{d_{max} = d_{min}\}$
    \{Anchors are within equal distant of the unknown node\} **use centroid localization**
  end if
end while=0

Figure 3: A pseudo code to implement the Linear Weighting Localization scheme.

4.2 Neighbor Weighting Centroid

Neighbor weight centroid is derived from WCL [20] which uses the distance and a static degree-factor value to compute the weights to associate to the anchors' coordinates. The use of a static degree-factor, as defined in WCL, results in an improved location accuracy compared to CL. However, a static degree-factor value may decrease the performance estimation of the WCL, since a degree-factor that leads to minimal error in one region of the field can significantly differ from the degree-factor that minimize the error in another region [24].

In NWC, the value of the degree-factor is computed dynamically using local information about the anchors' neighbor nodes and unknown node's neighbor nodes. NWC first computes the numbers of neighbor nodes between the unknown node and each of its corresponding anchors. These numbers describe how close anchor nodes are to the unknown node; larger values corresponding to closer anchor and lesser values corresponding to distant anchors. Then, the numbers are used to determine the degree at which each anchor node participates in the estimation of the node location. The algorithm is briefly described below.

Consider an unknown node i with n_i neighboring nodes. Let cn_{ij} being the number of common neighbor nodes between the unknown node i and neighbor anchor j. The neighbor weight centroid first estimates the distance between nodes i and j as in LWC, that is, using Equation (4). Then, the degree to which neighbor anchor j contributes to the localization estimation of node i is computed using Equation (8)

$$g_j = n_i - cn_{ij} \tag{8}$$

where g_j is the number of nodes that are within the coverage range of the unknown node i but out of the communication range of anchor j. This number is likely to increase as anchor nodes become farther from i and lesser as anchor nodes get closer to node i. Finally, the weight associated with anchor j, is then estimated as follows.

$$\begin{aligned} w_j &= 1/d_{ij}^{g_j} \\ &= 1/d_{ij}^{(n_i - cn_{ij})} \end{aligned} \tag{9}$$

Equation (10) ensures that anchor nodes with higher numbers of common neighbor nodes are assigned larger weights than distant anchor nodes. Let us, for example, consider two anchor nodes j and k within the radio range of unknown node i. Assuming that j is closer to i than k, then cn_{ij} is likely to be bigger than cn_{ik}. Therefore $n_i - cn_{ij}$ is likely to be smaller than $n_i - cn_{ik}$, meaning $d_{ij}^{n_i - cn_{ij}}$ is smaller than $d_{ik}^{n_i - cn_{ik}}$, yieldings a higher weight for anchor j than k.

After computing the weights, the location of node i is obtained as in the WCL algorithm, that is, using Equation (2). Fig. (4) proposes one way to implement the NWC localization algorithm. In contrary to the WLC algorithm,

while unknown node $i == true$ **do**
  Step 1:compute
  n_i\{Number of neighbor nodes\}
  Step 2: Poll neighbor anchor j and compute
  $d_{ij} \leftarrow 10^{(P_0 - P_{ij})/(10\theta)}$\{distance betwee i and j\}
  cn_{ij}\{Number of common neighbor nodes between i and j\}
  Step 3: for all neighbor anchors of i, extract their (x_j, y_j) coordinates and do
  $w_j \leftarrow 1/d_{ij}^{(n_i - cn_{ij})}$ \{weight of anchor j\}
  $(\hat{x}, \hat{y}) \leftarrow \left(\frac{\sum_{j=1}^{m} w_j \times x_j}{\sum_{j=1}^{m} w_j}, \frac{\sum_{j=1}^{m} w_j \times y_j}{\sum_{j=1}^{m} w_j}\right)$.
  return $(\hat{x}, \hat{y})$\{The location estimation is $(\hat{x}, \hat{y})$\}
end while=0

Figure 4: A pseudo code to implement the Neighbor Weighting Localization.

NWC algorithm computes the degree factor automatically and dynamically using only local information about an unknown node and its neighbor anchors, no prior analysis of the WSN is necessary in order to improve its performance.

It is worth to mention that the major challenge for RSS-based localization comes from the variations of the RSS due to the dynamic and unpredictable nature of the radio channels, such as multipath interference, reflection, refraction, obstacles interference..., in this case, techniques such as those used in [27] [28] [29] can be considered to improve the accuracy of the RSS and thus that of the estimated distance used in LWC.

5. PERFORMANCE EVALUATION

We performed comparative evaluations of centroid, NWC and LWC algorithms within a similar programming environment and scenario. Unless otherwise specified, all the simulations were performed on 500 nodes randomly distributed in a square area of 1000×1000 m^2 as illustrated in Fig. 5. where the stars and circles represent respectively the anchor

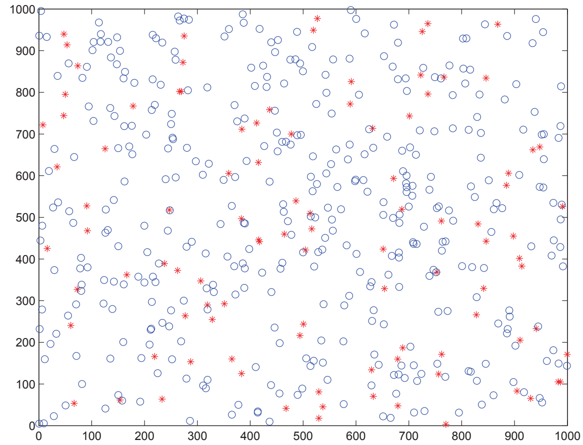


Figure 5: Nodes distribution diagram where '*' represents anchor nodes and 'o' sensing nodes

nodes and sensing nodes. There are 100 anchor nodes and 400 sensing nodes which locations need to be determine. We consider the classical model discussed in section IV for path loss propagation and estimate the distance between anchor and sensing nodes as indicated in Equation (4). Anchor nodes and sensing nodes all have a communication radius range of $200m$.

We study the effect of the number of anchors and the communication range of both the unknown and anchor nodes on the localization error. Localization error is computed using the following equation:

$$\xi = \frac{\sqrt{(\hat{x} - x)^2 + (\hat{y} - y)^2}}{R} \tag{10}$$

where ξ denoted the error in the localization process, R the communication range, and (x, y) and $(\hat{x}, \hat{y})$ respectively the exact and estimated coordinates of the unknown node.

5.1 Determination of LWC parameters

For LWC, the first issues to investigate are the choice of suitable values for parameters α and β when computing the values of the weights. In particular we are interested in the values of α and β that minimize the average localization error. Fig. 6 plots the average localization error versus α and β. The choice of these values are explained below. The figure shows that

- the average localization error decreases as α decreases and reaches its minimum in the region $0.01 \leq \alpha \leq 0.1$.
- the average localization error decreases as β increases until it reaches its minimum in the region $1 \leq \beta \leq 100$.

We therefore set the value of parameter α to 0.1 and the value of parameter β to 1.

5.2 Localization Map

Figs. 7(a) and 7(b) show the position of the sensor nodes before and after using LWC and NWC respectively. The short lines in the plots indicate how the algorithm has moved a sensor node from its exact position to the estimated position represented with a circle. LWC achieves an average

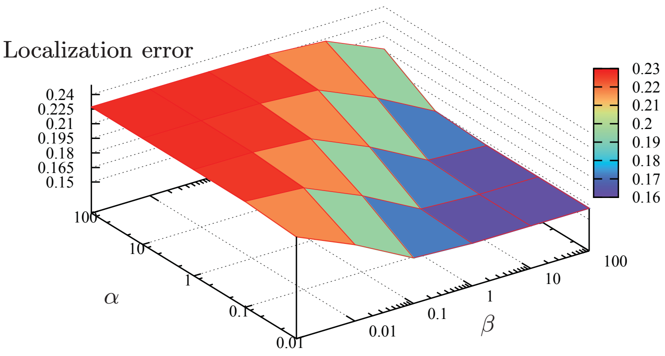


Figure 6: The localization error vs parameters α and β

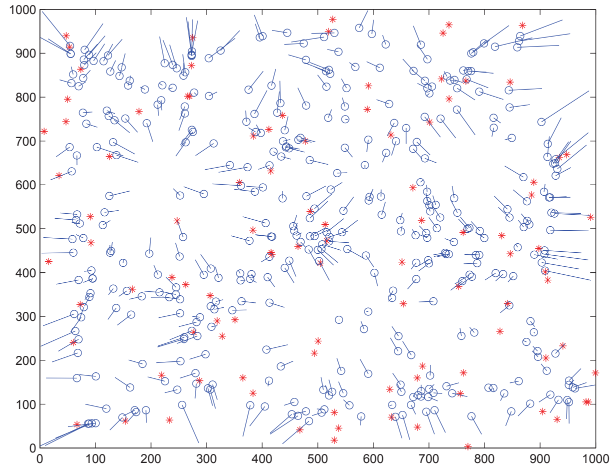
location error of 0.165 better than the 0.195 average location error achieved by NWC. This is due to the common neighbor nodes measurement in NWC, which reduced the estimated accuracy. However, both algorithms achieve lesser average error than the 0.225 obtained when using centroid.

5.3 Mean localization error when the Anchors' ratio is varied

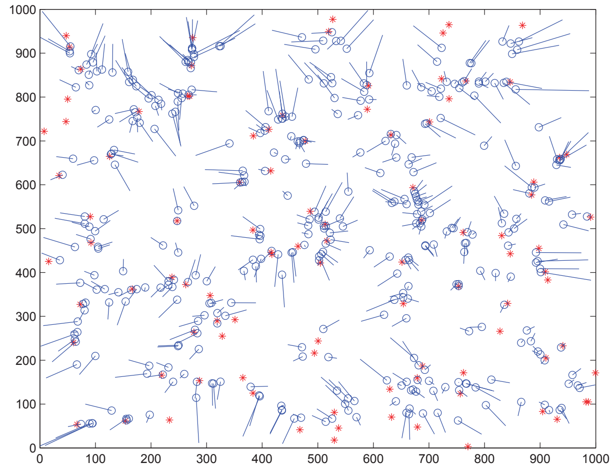
In Fig. 8, we plot the effect that a change in the ratio of anchor nodes given a constant number of sensing nodes has on the mean localization error. We chose to successively increase the ratio by 0.13, which corresponded to 15 additional anchor nodes. The mean localization error is estimated after each increase. We observed that the average localization error decreases as the number of anchors increases. Centroid localization shows a decrease in average localization error as the number of anchors increases. This is also observed with the two proposed algorithms, NWC and LWC. However, LWC and NWC have realized a smaller average localization error in general than the centroid. Overall, LWC realized better results than the NWC.

5.4 Mean localization error when communication range is varied

The cost of having a large number of anchors is however high. Therefore, instead of augmenting the number of anchors, we can increase the anchor radio range over which anchor nodes beacons travel. Fig. 9(a) shows the mean localization error trends when the communication range for anchor nodes increases. It is observed that for LWC and CL the mean localization error increases with increase in anchors' communication range, except for NWC where it generally remains constant. The increase is probably due to the fact that anchor propagation distance induces a larger cumulative error. The LWC and NWC still provide a smaller mean localization error than the centroid. An increase in communication range might not be an appropriate option while trying to reduce the mean localization error of unknown nodes. Fig. 9(b) illustrates the same scenario when the radio range of the sensing nodes increases. In this case the mean localization error for all three algorithms decreases with an increase of the radio range. LWC realized the best results of the three, with NWC performing better than CL.



(a) Positioning map using the LWC algorithm



(b) Positioning map using the NWC algorithm

Figure 7: Positioning map error

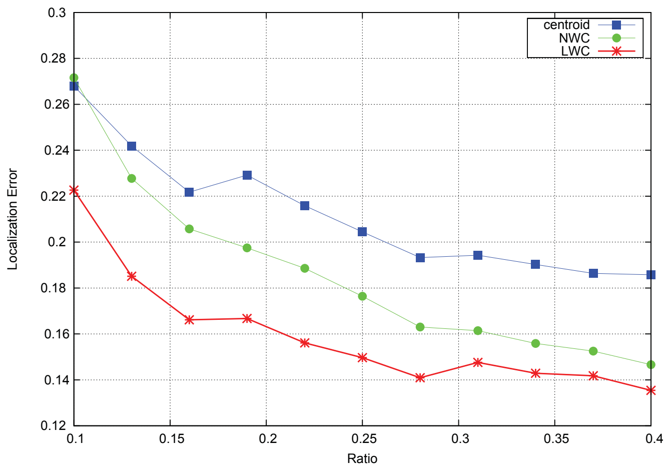
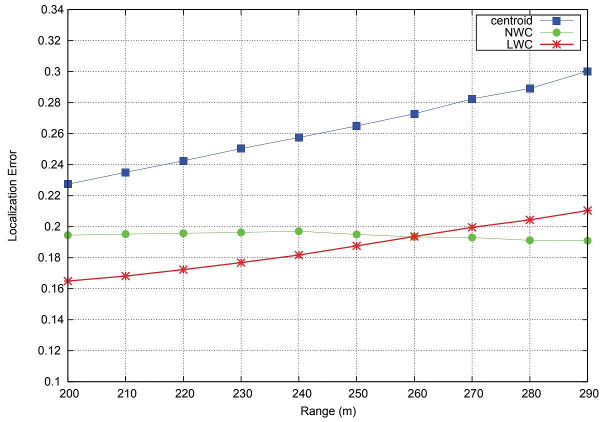
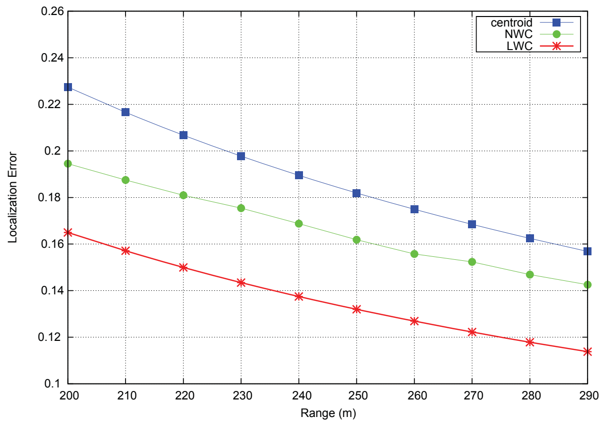


Figure 8: Mean localization error vs Anchors' ratio

Increasing the range of the sensing nodes is better than increasing the number of anchor nodes, if one wants to improve the node's localization accuracy. However this approach come with the cost of depleting sensing node energy, thus reducing the lifetime of the sensor network.



(a) Mean localization error vs anchor node's range



(b) Mean localization error vs sensing node's radio range

Figure 9: Mean localization error vs communication range

6. CONCLUSION AND FUTURE WORK

Wireless sensor networks provide the industries with remote monitoring and capability to automatically control their systems or devices. This paper highlighted the localization issue that a system designer needs to take into account when introducing WSNs in the industries. Two localization algorithms, the Neighbor Weighting Centroid (NWC) and the Linear Weighting Centroid (LWC) are proposed to improve the accuracy of centroid algorithm. LWC uses the distance between the anchor and the unknown nodes to linearly weight each anchor's coordinates. The weight assigned to an anchor's coordinates decreases linearly depending on the distance from the unknown node. NWC, on the other hand, uses the distance and the number of common neighbor nodes between an unknown node and its neighbor anchors to determine the degree at which distant anchor nodes participates in the localization process. The two proposed algorithms are compared to the classical centroid by means of simulation in a network environment of 500 nodes. Three parameters, the communication range of anchor nodes, communication range of sensing nodes and the ratio of anchor nodes are also varied in order to determine the performance trends of the proposed localization algorithms.

Simulation results show that both proposed algorithms perform better than the classical centroid in localization error reduction, with the linear weighting centroid realizing a much better results than the neighbor weighting centroid.

We intend to implement the two algorithms in a mobile wireless sensor network so as to reduce the energy consumes by nodes in the trilateration localization algorithm while keeping the localization accuracy at much better level than that of the centroid.

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