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Improving Energy Efficieny of Wireless Sensor Networks through Modified Localization Algorithms

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ABSTRACT: Wireless sensor network (WSN) is a new technology consisting of spatially distributed sensors for monitoring the physical or environmental conditions and a large number of wireless sensor network based applications are dependent on location, where the sensed data is useless without accurate location of target node. Localization is the fundamental problem in wireless sensor networks, because the location information can be used in various applications such as event detection, target tracking, monitoring applications in wireless sensor network. Location can also be estimated using Global Positioning System (GPS). But GPS does not work well in indoor applications and also it has drawbacks as high cost and increased energy consumption. In this paper, the localization of the target node in WSN can be estimated by communication-efficient decentralized algorithm in which the monitoring task can be formulated as nonnegative least squares problem. The proposed method uses the distance as an input interms of RSSI for decentralized Projected Jacobi (PJ) Approach where the optimization variable is a sparse vector which represents the location. The proposed method often converges faster and more communication efficient

KEYWORDS: Wireless Sensor Networks, Localization, RSSI, Projected Jacobi Approach

I. INTRODUCTION

The wireless sensor network shown in Fig.1 depicts the components of a sensor nodes for monitoring applications. Wireless Sensor Networks consist of three main components namely sensor nodes, communication and processing unit computations. The internal components of the sensor nodes are radio, battery, microcontroller, analog circuit, memory, signal conditioning, sensing unit and etc. The microcontroller in sensor node operates at a very low frequency. The spatial distribution of sensor node in the sensing field through the multi-hop communication is necessary to reach the high quality and fault tolerance in WSNs. The collected data is to be transmitted wirelessly through radio transceiver. Some of the applications of the wireless sensor networks include military applications, health applications, environmental applications and etc[7].

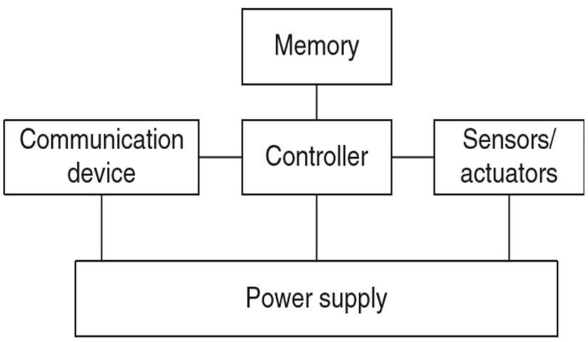

Fig.1 Components of Sensor Nodes

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In recent years, localization plays an important role in wireless sensor networks. For monitoring the environment, healthcare and military applications, the sensor nodes are distributed in a spatial manner. The data which is collected from the sensor node is passed through the network to the base station. Wireless Sensor Networks components include radiotransceiver with antenna, microcontroller, electronic circuit, battery, ADC and etc. Hence, the localization of the sensor node in wireless sensor network is a challenging task [1]. In many applications, GPS based location estimation has become tedious due to the higher cost, increased energy consumption [2]. Unlike GPS, the location is estimated using centroid algorithm but produces higher location error. There are two intelligent range-free localization schemes in which first scheme involves the Fuzzy Logic System (FLS) and Genetic Algorithm (GA). The second scheme includes the Neural Network (NN). But both the schemes are limited to indoor noisy applications [4].

Fuzzy based localization technique uses multilateration schemes which increases the localization accuracy with reduced positional error [5]. The node localization problem in mobile network can be formulated as fuzzy multilateration problem which is implemented in simulator. The simulation results show increased location accuracy from 20% to 40%. This method produces the low localization error without any extra hardware but the storage requirements of anchor is higher [6].

The following sections gives the description about wireless sensor networks of the location estimation and steps for estimating location.

II. LOCALIZATION TECHNIQUES

Localization is the determination of geographical locations of the sensor node. Localization is estimated through communication between localized node and unknown 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 which are listed in Table.1

Table.1 Various methods employed to estimate position

S.No	Method	Description
1.	Lateration	Distance between nodes is measured to estimate location
2.	Angulation	Angle between nodes is measured to estimate location
3.	Trilateration	Location of node is estimated through distance measurement from three nodes. intersection of three circles is calculated, which gives a single point which is a position of unknown node
4.	Multilateration	More than three nodes are used in location estimation
5.	Triangulation	Atleast two angles of an unknown node from two localized nodes are measured to estimate its position. Trigonometric laws, law of sine's and cosines are used to estimate node position

Location is estimated by means of angle or distance between the nodes and also uses connectivity or proximity data for estimating the position of the sensor. Generally, there are two types of localization techniques namely centralized and decentralized techniques.

Centralized Techniques: The fusion centre collects all the datas from sensor and position is estimated. The centralized techniques acquires a high communication cost because the data are transmitted from sensor in field to the fusion centre (i.e) sink node. In case, the fusion centre gets breakdown which leads to the loss of data and also failure of the event monitoring task takes place. Energy consumption is higher since all the nodes are in active state.

Decentralized Techniques: The decentralized approach needs the sensors to solve the optimization problem in an independent manner based on the local measurements.

Each node estimates its own position based on the local data collected from its neighbours at a low communication cost. The distributed localization can be grouped into range-based techniques and range-free techniques [2]. The graphical representation of decentralized technique is shown in Fig.2.

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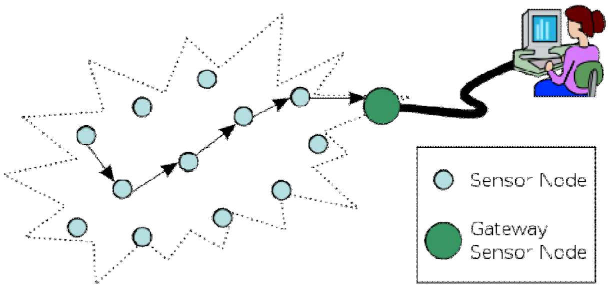

Fig.2 Decentralized node representation

Range-based scheme needs either node-to-node distances or angles for estimating the position of the nodes whereas in range-free techniques the node itself estimates the position by connectivity or proximity information. Range-based algorithm has higher location accuracy than range-free but require additional hardware to obtain distance or angles and also weak in noisy environment. Range-free algorithms are simpler than range-based algorithms but the results are not accurate. To reduce the communication cost of decentralized algorithms, one of the key is to reduce the amount of information exchanged per iteration.

III. METHODOLOGY OF LOCALIZTION PROBLEM

Decentralized algorithms namely Projected Jacobi (PJ) Approach method is used for estimating the location and magnitude of events with faster convergence rate. Received Signal Strength Indicator (RSSI) [5] has been given as an input and distance are obtained as an output using fuzzification. Various processes involved in the algoritm are shown in Fig.3.

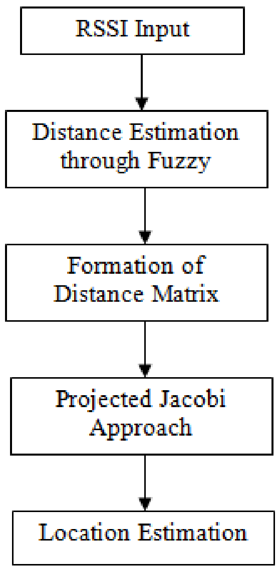

Fig.3 Processes involved in the localization

Bins are constructed as FAR, INTERMEDIATE and NEAR using the fuzzy rules [9]. Once the bins are constructed, defuzzification process takes place to estimate the location of the target node. The fuzzy distance output for each node was calculated using

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$$D_K=(a,b,c)=((\frac{\sum L_n}{|L|})_x,(P_c)_x,(\frac{\sum G_n}{|G|})_x) \qquad \text{eq. (1)}$$

Where the points P, L and G represents the fuzzy distance,

P – Centroid of all points in the column of FAR

L – Centroid of all the points in the column of FAR whose value is less than P.

G – Centroid of all the points in the column of FAR whose value is greater than P.

On substituting the values from the bins of FAR column in the distance (D_k) formula, the values of P, L and G are also obtained. The fuzzy ruler output for distance (bins) is constructed as given in Table.2

The fuzzy rule viewer is implemented using the fuzzy relationship between the input RSSI and the output distance. The input is categorized as WEAK, MEDIUM and HIGH with the range of -70 to -44dBm and the output is categorized as FAR, INTERMEDIATE and NEAR with the range of 0.1 to 1.1m. Using the fuzzy rule viewer, for input RSSI -57dBm the output distance obtained is 0.637m. Similarly, by varying input values the fuzzified output are taken which is shown in the Table.2 The monitoring task can be formulated into non-negative least square problem as

$$\min\left\{\frac{\lambda}{2}\|HC-b\|^2+\|C\|\right\} \qquad \text{eq. (2)}$$

Where,

C – Position and amplitude of the events

b – Noise polluted measurements by sensors

H – Measurement matrix derived from $h_{ij}=\exp\left\{\frac{-d^2{}_{ij}}{\sigma}\right\}$

d_{ij} – Distance between the sensors and

σ – Displacement co-efficient constant

Table.2 Construction of Bins

Far	Intermediate	Near
0.249	0.651	0.9
0.242	0.645	0.9
0.236	0.634	0.9
0.234	0.635	0.9
0.233	0.634	0.9
0.236	0.636	0.9
0.238	0.644	0.9

The main goal is to develop the communication-efficient decentralized algorithm to recover C for accurate location estimation. The eq. (2) can be solved through an iterative projected jacobi approach

$$C(t+1)=[C(t)-\gamma M^{-1}(P_c(t)+r)]^+ \qquad \text{eq. (3)}$$

Where,

M – Diagonal matrix whose diagonal elements equal to the corresponding diagonal elements of P

γ – Positive step size

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$P_c(t) + r$ -Gradient of the objective function of at C = C (t) of eq. (2)

The projected jacobi approach with the recursion eq. (3) converges to the optimal solution of eq. (2) if γ ε (0, 2/L) and also P must be positive semidefinite. The smaller stepsize γ assures the convergence. However, γ ε (0, 2/L) might be too conservative and could lead to slow convergence, it can be tuned to larger value in practice.When the influence range r_E is no longer than communication range r_C, the recursion eq. (3) is equivalent to

$$u_i(t+1) = C(t).h_i^t = \sum_{j\varepsilon N}^{i} h_{ij} C_i(t) \qquad \text{eq. (4)}$$

$$v_i(t+1) = \frac{1 - b\lambda h_i^t + u_i(t+1)\lambda h_i^t}{\lambda h_i^t} \qquad \text{eq. (5)}$$

The gradient function r is calculated using

$$r = 1 - \lambda H b$$

The unknown parameter b is given by

$$b = \sum h_{ij} c_j + e_j$$

On performing several iterations, the position of the sensor node is obtained. Furthermore, the projected jacobi approach converges faster and is more communication-efficient in each iteration.

IV. SIMULATION RESULTS

The obtained values from equations are utilized to detect the position of the sensor node by using the weighting parameters as 1 and 0.1 as shown in Fig.4 and Fig.5. The iteration starts at 3.8261 and on performing several iterations, the optimal solution is obtained at 8^{th} iteration with the value of 1.78 and same converged value is repeated till the 18^{th} iteration

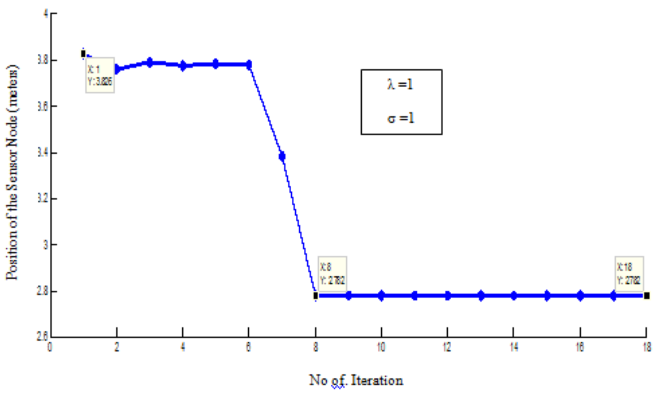

Fig.4 Location Estimation for λ =1, σ =1

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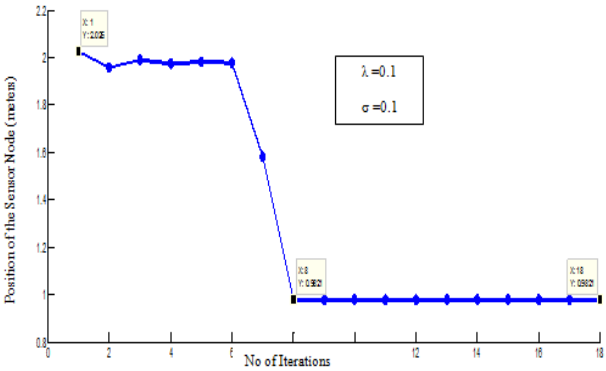

Fig.5 Location Estimation for λ = 0.1, σ = 0.1

The results describe that the error is converged to obtain the optimal solution and also estimates the position and magnitude of the events C. For different values λ and σ, the convergence time differs for the same co-ordinate estimation. Hence, the consumed by sensor node looking after location estimation is limited by reducing convergence time.

V. CONCLUSION

Location estimation plays a major role in wireless sensor network for various applications. The proposed jacobi methods determined the location of node in which each sensor only cares about the event occurring at its own position. The simulation results also proved that the position was estimated with minimum number of iterations (i.e.) faster convergence than the existing methods. The communication cost per iteration was reduced and also provided efficient communication. The results obtained from the decentralized techniques proved that PJA method reduces error by 20% than centroid methods. Further, the results obtained from projected jacobi approach may be compared with other decentralized techniques namely Alternating Direction Method of Multipliers (ADMM), distributed subgradient method, distributed dual averaging algorithm, etc. in order to reduce the localization error for implementing in real time.

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