Int J Pharm Bio Sci 2016 April; 7(2): (B) 363 - 370

Review Article **Computer Science**

International Journal of Pharma and Bio Sciences

ISSN 0975-6299

AN APPROACH TO LOCALIZATION IN WIRELESS SENSOR NETWORKS USING MULTIDIMENSIONAL SCALING AND DISTANCE VECTOR HOP

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ABSTRACT

In this paper we have exhibiting localization as vital issue in wireless sensor network that involves the union between sensor nodes so that localization can be able by the nodes themselves. In this context we have presented a unique combination of Multidimensional Scaling (MDS) localization which is centralized for mapping with Distance Vector (DV) algorithm. In MDS-MAP a local map is built at each node that is very adjacent then these maps are fused to form a global map. The Goal of MDS is to maintain the distance information and consequently network can be recreated in multidimensional space. MDS is partially range aware, when this is combined with DV Hop localization which is range free algorithm to calculate the average hop distance and average hop counts for better localization.

KEYWORDS: Sensor nodes, Localization, Multidimensional Scaling, Distance Vector-Hop, Wireless Senor Networks, Mapping.

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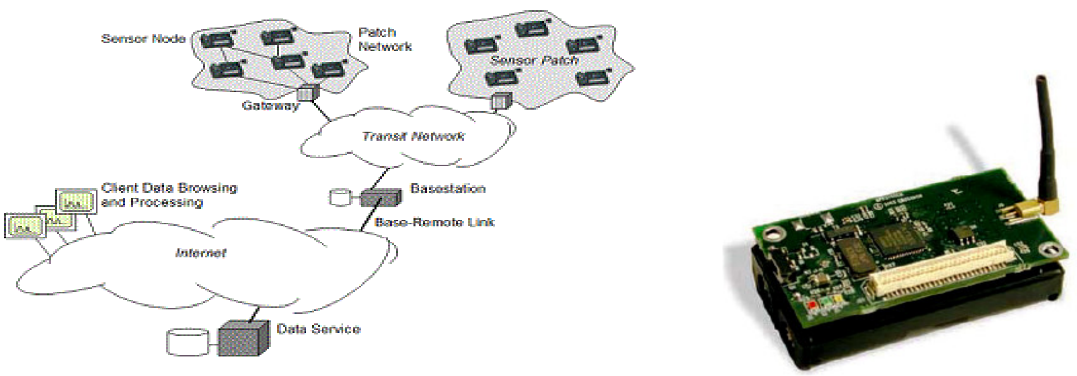
INTRODUCTION

In Wireless Sensor Network (WSN)[1], sensed data make no sense without the nodes position information. Hence, nodes are required to locate themselves in many WSN applications, such as environment monitoring, emergency rescue, and battlefield surveillance etc. A lot of protocols and algorithms are designed to solve the node's positioning problem, which are categorized into two broad categories: range-based and range-free[2]. Range based protocols used to calculate the location in point-to point distance or angle estimates. Likewise range-free methods will not depend on angle estimations or range; hence no expensive hardware is required. Therefore taking this into account researchers find the range free methods for localization as a cost effective option. A WSN is a collection of nodes organized into a cooperative network. Each node consists of processing capability one or more microcontrollers, Central Processing Units (CPU) or Digital Signal Processing (DSP) chips, may contain multiple types of memory program. The data and flash memories, have a Radio Frequency (RF) transceiver usually with a single Omni-directional antenna, have a power source e.g., batteries and solar cells, and accommodate various sensors and actuators. Multidimensional Scaling algorithms give high accuracy and low communication and computation cost reducing noise and propagation delay. Wireless Sensor Networks[1] consists of hundreds or thousands of sensor nodes that sense and communicate with each other with low cost small size and easy installation. Due to the data collected by the sensor node, in the monitored area, it is useful only when its location information is known. Node positioning as a critical technology and is the basis of application of wireless sensor network. In this paper, Multidimensional Scaling has been applied to node localization. Further, MDS[13] based localization algorithm are introduced and analyzed combined with Distance vector[3] The simple idea is to find the distance between new nodes and the place nodes has been articulated by the product of average hop value and the hop count. Figure 1 a & b shows a typical wireless sensor network and a sensor, A *sensor* is a transducer used to sense that is, to detect some features of its environments. It detects events or changes in quantities and provides a relevant output, usually as an electrical or optical signal.



a b

Figure 1
a. Wireless Sensor Network b. Sensor

The Global Positioning system[5] that is been installed on to the sensors in functioning of Wireless Sensor Network is not helpful to use because of elevated power consumption, higher cost. The Multi-Dimensional Scaling will map the objects starting from a higher dimensional to a lower dimensional space despite the fact maintaining the distance among objects**.**

In the DV-Hop algorithm[18], taken between beacon nodes as the average distance per hop beacon nodes unknown node to the average distance per jumping, jumping distance and jumping through each multiplied by the number to represent the unknown nodes and beacon nodes the distance between. However, in actual network topology beacon node to the node that is unknown is often not a straight path.

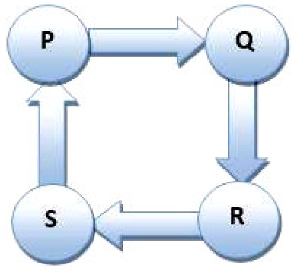


Figure 2
Node Paths

Consider Figure 3 take any four nodes P, Q, R, S. Assuming the beacon node a node, the distance between the beacon nodes of 1m. Since DV-Hop algorithm, for unknown node d, a beacon node to the unknown node d is the distance 4m. However, this distance is much larger than the actual distance between two points, as the beacon node a to unknown node d paths that are not straight connection DV-Hop localization algorithm[19] assumes that the network average hop distance is the same, thereby reducing the positioning accuracy, especially when unknown beacon node under test and beacon node is one hop distance. In fact, one hop distance can be shorter or longer, not completely equal. The flow of the paper is as described first we present localization a basic approach in later, we present proposed work which discusses Distance Vector Hop and DV Hop localization, next MDS is discussed, then steps for MDS mapping is described later In the next section MDS based algorithm is illustrated and analyzed. Later DV is analyzed In Section and finally give the conclusions.

LOCALIZATION

Localization is a mechanism for discovering spatial relationships between objects a basic localization is shown in figure 2.

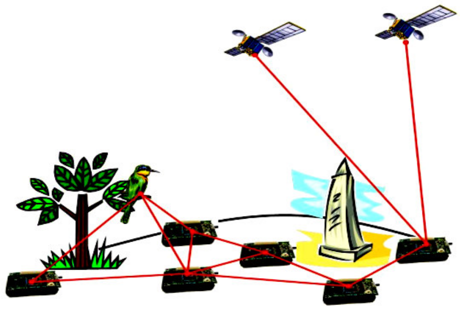


Figure 3
Localization

Localization is broadly classified based on range estimation as range based and range free[4].The former algorithm can be applied between physical elements where the distance between the anchor/beacon and the node is known. In case of Global Positioning System[5] the Time of Arrival (TOA) property is used to measure the range. In case of MIT'S Cricket[6] makes use of Time difference of Arrival (TdoA) to measure the range, the same thing is applied in APS[10] as well. Angle of Arrival (AOA)[8] is widely used to estimate relative angle between two nodes, later to measure the distance. The range free systems does not require the physical distance connected properties, for instance we can measure the count of number of hops between an anchor point and a sensor node, and later convert the hop counts to physical distance as done in[9]. Another instance is making use of Centroid related properties to estimate locations within confined radio range.

The basic MDS-MAP algorithm

Given connectivity or local distance measurement, compute shortest paths between all pairs of nodes. Apply multidimensional scaling (MDS) to construct a relative map containing the positions of nodes in a local coordinate system. Given sufficient anchors (nodes with known positions), e.g., 3 for 2-Dimensional or for 3-Dimensional networks, convert the respective map and determine the complete map and the positions of nodes. It works for any n-dimensional networks, e.g., 2-D or 3-D.Here we highlight on the sensor location problems based on previous work, this can be categorized into four major modules or the permutations of the same. Method one deals with various signal procedures to improve the exactness of distance estimation. The Received Signal Strength Indicator (RSSI)[16] was employed. Method two depends on set of nodes whose positions are known called as anchor nodes or beacon nodes with respect to which the sensor positions are organized in the form of grids and calculate the positions near to them. The third technique makes use of algorithm that not only deals with number of communication cost but cannot generate position at some instances the last method locally calculates maps of adjacent nodes with Trilateration or multilateration and pieces them together to estimate nodes' physical or relative positions. Multi dimensional Scaling Map (MDS-MAP) Algorithm[10]. In this particular algorithm it makes use of connectivity information within confined communications range. This has following steps.

Step 1
Compute shortest paths between all pairs of nodes, the distance matrix takes O (n^3) time, where n number of nodes.

Step 2
Apply MDS to the distance matrix takes O (n^3) time.

Step3
Transform the relative map to an absolute map based on the exact positions of anchors which takes O (m^3) time, where m is the number of anchors. Applying the transformation to the whole relative map takes O (n) time. With three or more anchor nodes. A drawback of MDS-MAP is that it requires global information of the network and centralized computation and will not work well on irregularly-shaped networks and takes O (n^3) time. In Improved MDS-Based algorithm[11] called MDS-MAP (P). The main intension is to construct a local map at each node, that consists of only nearby nodes later merge them as per relative maps to form a global solution Disadvantage of MDS- MAP (P) is that merging local maps to form global maps is very complicated phenomenon and this restricts weights to be either 0 or 1. In Distributed Weighted-Multidimensional Scaling for Localization (dwMDS) [12.dwMDS] is a scalable decentralized algorithm that emphasizes the most accurate range measurements for node localization. This is enabled by a weighted cost function that more heavily weighs measurements believed to be more accurate. The majorization stage has the property that each iteration is guaranteed to improve the cost function and takes O (LN) time. Where L is number of iteration and N is number of node. It has great communication with neighboring nodes because in each iteration transmits its estimated location and local stress to neighboring nodes. It does not have the complex step of merging local maps together to form the global map. A drawback of dwMDS is that complexity, convergence time, high communication cost and initial estimate requirements. In Hierarchical MDS-based Localization Algorithm (HMDS)[12]. This has following steps

Step 1
HMDS partition the network into multiple clusters, each cluster has head.

Step2
The cluster head can compute distances of all pairs of sensors.

Step3
Cluster head applies a multidimensional scaling algorithm on a distance matrix computes the relative coordinates of each cluster member and forms a local map.

Step 4
Each cluster with at least two cluster merge to form global/unified coordinate system. The disadvantage of HMDS is the roughly high error margin and requires complex setup for merging local maps together to form the global map. In Alternative Least-Square Scaling Algorithm (ALESSA)[13] for localization. This is a centralized algorithm and uses Least-Square stress function. A drawback of ALESSA that it is centralized algorithm.

PROPOSED WORK
DISTANCE VECTOR HOP

DV Hop[15] makes use of a heterogeneous network that comprises of sensor nodes and beacon nodes, rather than broadcasting the single hop the beacons will flood their location to compute network and maintain the hop count at all respective nodes, The nodes in turn evaluate their position with respect to beacon nodes location, the average distance per hop and the respective hop counts from the corresponding beacon, a value is obtained via beacon communication.

DV HOP LOCALIZATION

DV Hop localization[15] makes use of the technique that is very close to basic DV routing. Here every anchor node will exhibit transmission of a beacon that must be flooded to complete system with the initial hop count one. All the reception node maintain the minimum hop count values and ignore the one with higher or maximum hop count values. Later floods beacons with each step the hop count is incremented at every intermediate hop, which will result into shortest distance in hops to every anchor. Figure 4 shows the organization of nodes propagation with respect to anchor A.

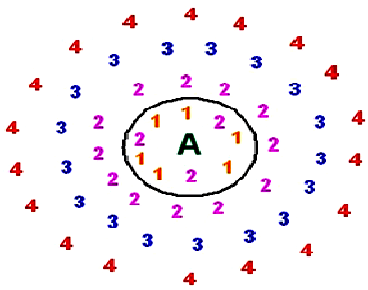


Figure 4
DV Hop localization beacon nodes propagation with respect to anchor A

Therefore we can estimate the average single hop distance by the formula

$$hopsizex = \sum\frac{\sqrt{(ax-ay)^2-(bx-by)^2}}{\sum hy}$$

Where ay, by is location of anchor y, and hy is distance in hops from anchor y to anchor x.The main advantage of Distance Vector Hop localization is not prone to errors of range measurements, and does not require any complicated hardware to measure.

MULTIDIMENSIONAL SCALING

Multidimensional scaling (*MDS*) can be considered to be an alternative to factor analysis. In general, the goal of the analysis is to detect meaningful underlying dimensions that allow the researcher to explain observed similarities or dissimilarities (distances) between the investigated objects. In factor analysis, the similarities between objects (e.g., variables) are expressed in the correlation matrix. With MDS one may analyse any kind of similarity or dissimilarity matrix, in addition to correlation matrices. Figure 5 gives a simple illustration of MDS scaling.

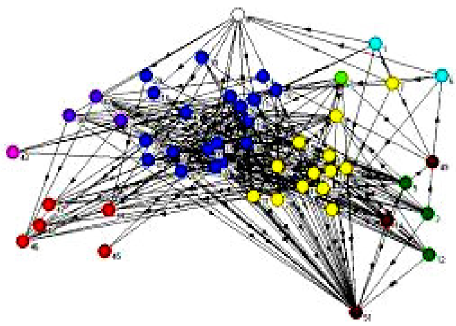


Figure 5
Multidimensional scaling

PROBLEM DEFINITION

Known: A set of N points in a plane
Coordinates of 0 ≤ K<N points (*anchors*)
M ≤ N x (N-1) distances between some of the points

To be found
Positions of all N- K points (found unknown coordinates)
Abstraction: WSN can be abstracted with graph
Nodes in WSN~ vertices in graph
Distance between nodes~ edges in weighted graph
Graph realization (~ find coordinates of the vertices using length of the edges)
Multidimensional scaling (MDS) is well-known technique used for dimensionality reduction when we have multidimensional data MDS minimizesσ^2. Using MDS compute shortest paths between all pairs using Bellman ford or Floyds algorithm combined with DV Hop localization, the main advantage is no additional beacons or anchor nodes are required as MDS uses centralized computation or globalization.

STEPS FOR MDS-MAPPING

Multidimensional Mapping can be performed as follows[16,17]
(a) Shortest distance between each pair of nodes is calculated using either Dijkstra or Floyd's all pair shortest path algorithm. This is the distance matrix that serves as input to MDS in step 2.

(b) Classical MDS is applied to distance matrix.

(c) Transform relative map into absolute map given sufficient number of nodes.

PROPOSED ALGORITHM

Algorithm to illustrate Floyd used in MDS to compute shortest distance from all nodes to all other nodes
Input: Cost adjacency matrix of size n*n
Output: Shortest distance matrix of size n*n

Step1
Cost adjacency matrix
For i<-0 to n-1 do
For j<-0 to n-1 do
D [i, j] = cost [i, j]
End for
End for

Step 2
Shortest distance from all nodes to all other nodes

For k<-0 to n-1 do
for i<-0 to n-1 do
for j<-0 to n-1 do
d[i,j]=min(d[i,j],d[i,k]+d[k,j])
end for
end for
end for

Step 3
complete return

ANALYSIS AND RESULTS

The runtime of the algorithm is time required to execute step 2

$$\sum_{k=0}^{n-1} \sum_{i=0}^{n-1} \sum_{j=0}^{n-1} 1$$
$$= \sum_{k=0}^{n-1} \sum_{i=0}^{n-1} n-1-0+1$$
$$= \sum_{k=0}^{n-1} \sum_{i=0}^{n-1} n$$
$$= \sum_{k=0}^{n-1} \sum_{i=0}^{n-1} 1$$
$$= \sum_{k=0}^{n-1} n(n-1-0+1)$$
$$= \sum_{k=0}^{n-1} n(n)$$
$$= \sum_{k=0}^{n-1} n^2$$
$$= n^2 \sum_{k=0}^{n-1} 1$$
$$= n^2(n-1-0+1)$$
$$= n^3$$

DV-HOP LOCALIZATION ANALYSIS

This has three stages. A traditional distance vector technique is applied, beacons flood their location to entire network with initial hop count=0.Every beacon after getting the information of hop count and position, estimates the average distance per every hop. Beacon I calculates the average distance per hop called as HS hop-size using

$$HSi = \sum j \neq i \frac{\sqrt{(xi-xj)^2+(yi-yj)^2}}{\sum hj}$$

Where (x_i, yi) and (x_j, yj) are coordinates of beacons, i& j respectively and $H_j$is value of hop count from beacon i to beacon j.

Every single sensor calculates the distance to every beacon depending on hop size and hop count. Sensor k can get the distance d_{kj} (distance from sensor k to beacon j) asDkj=$H_j * HS_i$which calculates its own location.

The graph below shows using the tabular values of number of nodes and time in seconds to localize these nodes, MDS combined with DV gives better localization with range free centralized system.

Table 1
Contains number of nodes and time

Sl no	Number of nodes	Time in m sec
1	1	5
2	2	10
3	3	15
4	4	20
5	5	2

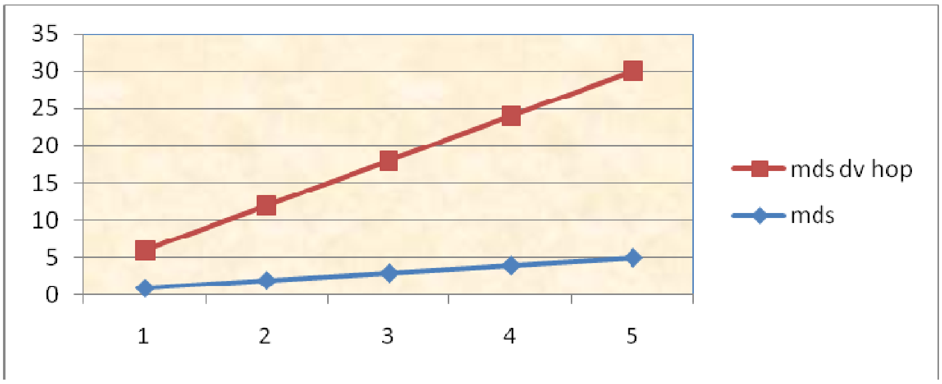


Figure 6
Graph shows MDS compared with MDS DV Hop x- axis is number of nodes y- axis is time

CONCLUSION AND FUTURE ENHANCEMENT

In this paper, We present an algorithm of Multidimensional Scaling method combined with Distance Vector hop localization in detail and analyzed which has the main advantages like no additional beacons or anchor nodes are required because MDS uses centralized computation and also Distance Vector Hop localization is not prone to errors of range measurements, and does not require any complicated hardware to measure so it's very cost effective. The main contribution of this paper: (a) integrated localization scheme has been proposed on the basis of MDS-DV, (b) Proposed localization method of incorporated MDS-DV gives better efficiency than O (n^3) due to added features of centralized aspect of MDS and DV doesn't require sophisticated hardware serves better than existing systems. For future work we intend to invent an algorithm on distributed networks and for irregular topologies.

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