Localization of Sensor Nodes in Wireless Sensor Network

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ABSTRACT
Wireless sensor networks (WSNs) are networks of distributed autonomous devices and use large number of sensor nodes that contains a processor, memory, wireless communication capabilities, sensing capabilities and a power source (battery) on-board to form a network. Developers of WSNs face challenges that arise from communication link failures, memory and computational constraints, and limited energy. Localization of sensor nodes in wireless sensor network plays an important role in many applications. It is important to monitor the location of the data source and event occurrences to track the target and phenomena. Localization in wireless sensor networks means estimating the position or spatial coordinates of wireless sensor nodes. This paper mainly focuses on the localization of sensor nodes using centralized and distributed localization techniques.

General Terms
Centralized Algorithms, distributed Algorithm.

Keywords
Wireless Sensor Network, Localization, Particle Swarm optimization

1. INTRODUCTION
Wireless Sensor Network (WSN) is a network of distributed autonomous devices and use large number of sensor nodes that are equipped with a processor, memory, wireless communication capabilities, sensing capabilities and a power source (battery) on-board to form a network[1]. A wireless sensor network with a large number of sensor nodes can be used as an effective tool for gathering data in various situations. Each node in a WSN is able to sense the surroundings, process that information locally and send it to one or more number of destinations through a wireless link. WSN can be developed at low-cost and is typically formed by deploying many sensor nodes in an ad hoc manner. All these nodes sense physical characteristics of the world. The sensors can measures a variety of properties like temperature, humidity, light, pollution and acoustics. Sensor nodes are groups as clusters and one node in cluster act as a cluster head. All the nodes forward their sensor data to cluster head which in turn routes it to sink node or base station through a multi-hop communication. Base stations are responsible for sending queries to and collecting data from the sensor nodes.

Some of the main characteristics of a networked sensor include:

- Compact size
- Low power consumption
- Limited processing power
- Short-range communications
- Small amount of storage.
- Physical security

Localization is an area that has much attention in recent years. A fundamental problem in designing sensor network is localization. Localization means determining the location of sensors. The location information can be used to detect and record events, or it can be used to route packets using geometric-aware routing. The Localization becomes a fundamental problem in Wireless sensor networks as the nodes should know the positions of sensors. With the constrained resources of network sensors, as well as their high failure rate, many challenges exist in using them to locate objects. This paper mainly focuses on the localization of sensor nodes using the Centralized and Distributed Localization techniques.

This paper organized as follows:

Section II: Describes the Localization of sensor nodes using Centralized Algorithm.

Section III: Describes the Localization of sensor node using Distributed Localization Techniques.

Section IV: Describes the Localization of sensor node using Particle Swarm Optimization

Section V: Describes the Comparison of Localization using Centralized, Distributed and PSO Techniques

Section VI: Describes the Conclusion

2. LOCALIZATION OF WIRELESS SENSOR NETWORK
A WSN consists of a large number of low- cost smart sensors with limited computational capacities and energy resources. There is no fixed infrastructure for the WSN so the sensors move in an uncontrolled manner. In all most all WSN applications the sensed data are related to the location of the sensors many researchers have focused on the localization problem. To equip sensors GPS is the first solution for the localization problem in sensors. This solution is non-practical in WSN because GPS is very expensive and consumes high energy and also they have great size. For sensor localization many anchor based algorithms have been proposed. Doherty et al. propose a centralized technique for position estimation is an example for this. In this localization is formalized as convex optimization problem having connectivity measurements between sensor constraints. Local maps with relative positions are constructed using measured distances between nodes and their neighbors. A combination of these maps with known positions of anchors leads to absolute

positions. Nevertheless, these techniques are not very robust, because of errors accumulation while combining the maps.

Localization has been categorized into different techniques as

- Centralized Localization
- Distributed Localization

2.1 Localization of Sensor Node using Centralized Localization Techniques

In centralized algorithms techniques, there is a central processor which collects the information from each sensor node. This approach attempt to obtain maximum accuracy. Centralization requires the movement of the related node connectivity data and ranging to a centralized base station and then the movement of respective locations return to the related nodes. Centralized algorithms are quite complex with respect to Computation. The advantage of centralized algorithms are that it reduces the problem of computation in each node, at the same time the there are certain limitations in the cost of communication of getting data back to the base station. Due to limited power supply for each node transmission of data from the sensor nodes to a central base station is very expensive. Eventually, transmitting time series data within the sensor network results in latency and which also uses energy and bandwidth.

Multidimensional scaling is used in MDS-MAP centralization algorithm developed by Shang et [6]. This algorithm works on three steps those are as follows:-

Step 1: First gather data from the network and with the help of Dijkstra's algorithm, construct distance matrix by implementing the shortest path computed.

Step 2: Run classical MDS (Multi-Dimesnional Scaling) to calculate estimated location for each node.

Step 3: To reduce the error between the correct position and absolute position of each node transform the relative position map into absolute position map that helps.

As ranging improves MDS-MAP location estimates also improves [2]. Some disadvantages lies with MDS-MAP is that it all the information about the network and centralized conditions. The neighbor sensor nodes and accesses the computed locations. It has been described with two steps. In the first step, simulated annealing is used to achieve the location estimate of the sensor nodes with the help of distance constraints. In the second step, some errors are removed with the help of flip ambiguity.

2.2 Localization of Sensor Node using Distributed Localization Techniques

Distributed localization technique, do not want a large centralized computer. This technique gives better scalability [2]. In Decentralized or distributed localization techniques, each sensor node gives limited communication with the closer sensor nodes to get the location information [4]. All the required computations can be done on the sensor node themselves in these algorithms and the sensor nodes communicate between one another to get their exact position within the network [3].

2.2.1 Localization of sensor node using Beacon-Based Distributed Algorithms

From beacon positions unknown node positions can be estimated in this algorithm. All the required computations can be done on the sensor node themselves in these algorithms. The nodes can be localized into the beacons area [2]. Beacon-based algorithms can be categorized into four approaches: Bounding box, diffusion, APIT and gradient [10 11 12 13 14]. This paper focus on two approaches those are bounding box and diffusion.

2.2.1.1Bounding box:

This approach is computationally simple method of localizing nodes given their ranges to several beacons. This algorithm is a method [8] [9].where nodes can be localized within the range of many beacons. For each node it creates a bounding region and starts filter their right positions. The collaborative multilateration helps nodes get their location estimate appropriately through identified beacon positions which are hops away [3].Bounding box algorithm gives accurate results, when the node's position is closer to the centre of the beacon nodes.

2.2.2.2Diffusion algorithm

In diffusion the most likely position of the node is at the centroid of its neighboring uknown nodes. Bulusu et [7] propose the localization of the unknown nodes by getting the average positions of all beacon nodes with which the node is having radio connectivity. The advantage of diffusion algorithm is in the networks where nodes need to do less computation [2].

2.3 Localization of Sensor Node using Particle Swarm Optimization

Computational Intelligence has an important role to solve technological problems and it is appropriate for uncertain and nonlinear formulations. In fact, CI attempts to achieve tractability, robustness and low solution cost. The Localization can be formulated as a multidimensional optimization problem, and tackled by using Particle Swarm Optimization (PSO).

2.3.1 Determination of Location of Target node

The base station runs a 2n-dimensional PSO (x and y coordinates of n nodes and M= base stations). Gopakumar et al. have proposed PSO-Loc for localization of n target nodes out of m nodes based on the a priori information of locations of m-n beacons [5]. Here, (x; y) is an estimate of the target node location, (x_i; y_i) is the location of beacon node i, and is the number of beacons in the neighbourhood of the target node. Estimated distance from beacon i,, is simulated as the actual distance corrupted by an additive Gaussian white noise. The inconsistency of noise influences the localization accuracy. The approach does not take into account the issues of flip ambiguity and localization of the nodes that do not have at least three beacons in their neighborhood. The scheme works well only if either beacons have sufficient range, or there exist a large number of beacons. Moreover, the base station requires range estimates of all target nodes from all beacons in their neighborhoods. This requires a lot of communication that may lead to congestions, delays and exhaustion of energy. In addition, the proposed scheme has a limited scalability because the PSO dimensionality is twice the number of target nodes. WSN localization is a two phase process which includes ranging phase and Position estimation phase. Whatever be the ranging method, there will be measurement errors in practical localization systems that result in noisy range estimations. Here proposed an optimization approach that minimizes the error in locating the coordinates of the target Nodes based on Swarm Intelligence called Particle Swarm optimization (PSO) [5].

2.3.2 PSO-Iterative

Each target node that has three or more beacons in its hearing range runs PSO to minimize the localization error. Nodes that get localized act as beacons for other nodes. This continues iteratively, until either all the nodes get localized, or no more nodes can be. This method does not require that each node transmit it range measurement to a central node. Besides, it can localize all nodes that have three localized nodes or beacons in their range. As the localization iterations pass by, a node may get more number of references for localization, which mitigates the flip ambiguity problem, the situation that results in large localization error when the references are near-collinear. However, the proposed method is prone to error accumulation [5].

2.3.3 PSO- Beaconless

The nodes are deployed by an unmanned aerial vehicle equipped with a position sensor. The exact location φi of a node i is treated as the conditional probability density function of φdi, the location where the node is deployed (which is recorded by the use of a pedometer). If this node can receive a signal from a localized node j it can estimate its distance dj . A likelihood function for exact location is expressed in terms of φdi and dj . PSO minimizes one term of this likelihood function. The results of two variants of the algorithm are presented. Results show fairly accurate localization even in sparse deployment it is reported that PSO takes longer computational time, but perform as accurate localization as the Gauss-Newton algorithm does when the pedometer accuracy is high. However, in less accurate pedometer records, the PSO outperforms the Gauss-Newton method in terms of localization accuracy [5].

3. COMPARISON OF LOCALIZATION USING CENTRALIZED, DISTRIBUTED AND PSO TECHNIQUES

Localization algorithms performance depends on the factors such as anchor density, node density, communication cost, computation cost and robustness, hardware dependency power usage and maintainability and so on. All these approaches have their own advantage and disadvantage that makes them suitable for different applications. Some algorithms requires beacons especially for distributed algorithms such as Diffusion, Bounding box, Gradient and APIT and some do not have like centralized algorithms such as MDS-MAP, Relaxation based localization scheme, Coordinate system stitching. Beaconless algorithms produce relative coordinate system that can be registered to a global coordinate system. Sensor network do not require a global coordinate system. Such situation beaconless algorithm is sufficient. Centralized algorithms give more importance to accuracy. This computes more accurate positions and can be used in the situation where accuracy is important. Distributed System does not depend on large central processor so it shows better scalability than the centralized. Cost and battery life is also an important factor in the case of sensor network. In the case of centralized techniques the communication cost is more because the central processor needs to send the data back to the base station. The MDS-MAP has higher computation cost and communication cost and performs well when few anchor nodes are. PSO can be used in both centralized and distributed localization techniques. It can minimize the localization error in centralized and distributed Localization techniques. Easy implementation on hardware or software. The optimization problem in wireless sensor network PSO has been widely used because of its simplicity, high quality of solution, fast convergence and insignificant computational burden. Iterative nature of PSO can prohibit its use for high-speed real-time applications. PSO can also be used where optimization needs to be carried out frequently. PSO requires large amounts of memory, which may limit its implementation to resource-rich base stations.

4. CONCLUSION

Application of wireless Sensor Network includes the collection of data from different location and process the data. Therefore, it is an important task to know the location of data from where that has been collected. Wireless sensor networks became a key technology that is used in many industrial and environmental problems. Defining an effective localization algorithm became an important task. Wireless sensor network have many challenges. Nowadays, many approaches are used for localization of sensor node. Researchers have made great efforts and a variant of algorithm also proposed. This paper focused on classification for localization techniques. That includes the study of three algorithms; those are Centralized localization Technique, Distributed Localization Technique and Particle Swarm Optimization Technique. First is the localization of sensor using centralized algorithm. Centralized algorithms are quite complex with respect to Computation. The second is the localization of sensors using distributed algorithm. To reduce error during localization, use new means to approximate the distance between unknown nodes and anchor nodes when it is larger than node's communication radius. Moreover, the particle swarm optimization to calculate the similar position of nodes; it makes the localization error much lower than the common method. Many of the localization algorithms look promising; still there are many challenges that need to be solved.

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