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Localization algorithm techniques for sensor node in wireless sensor network

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Abstract-*Localization is a way to determine the position of sensor nodes. It is very important to know about the location of data. This information can be obtained using localization technique in wireless sensor networks. Acombination of distance and direction measurement techniques introduced to estimate ranges not require any hardware and its cost effectiveness as compare to rangebased algorithm techniques. This paper provides an overview of Range based and Range free techniques in wireless sensor network.*

Keywords:Wireless sensor network,Localization algorithm techniques.

1. INTRODUCTON

Wireless Sensor Networks (WSNs) consist of numerous nodes, which have several modules, including receiver and transmitter. Generally, WSNs have many advantages due to its low cost and low power dissipation [1]
WSN is used in various fields such as military affairs, medical field, target tracking, environmental and habitat monitoring and Precision Agriculture. In all the applications sensor nodes detect events or gather data from particular locations. Therefore event gathering without the knowledge of locations is meaningless [2]

- Range-based algorithms
- Range-free algorithms.

Range free techniques are cost-effectiveness, energy efficiency and no need of additional hardware for localization as compare toRange-based techniques. But disadvantage of range free techniques has its low communication range. Range based techniques include Received signal strength(RSS), Time of arrival(TOA), Time difference of arrival(TDOA), Angle of Arrival(AOA). While Range free techniques include centroidalgorithm, APIT algorithm and DV-Hop algorithm. Among them centroid and DV-Hop are widely used [3]

2. LOCALIZATION

To determine the physical coordinates of a group of sensor nodes in a wireless sensor network (WSN).To Report data that is geographically meaningful Services such as routing rely on location information, geographic routing protocols, context-based routing protocols, location-aware services. In general, almost all the sensor network localization algorithms share three main phases.

2.1 DISTANCE ESTIMATION

The distance estimation phase involves measurement techniques to estimate the relative distance between the nodes.

2.2 POSITION COMPUTATION

The Position computation consists of algorithms to calculate the coordinates of the unknown node with respect to the known anchor nodes or other neighbouring nodes.

2.3 LOCALIZATION ALGORITHM

The localization algorithm, in general, determines how the information concerning distances and positions, is manipulated in order to allow most or all of the nodes of a WSN to estimate their position. Localization algorithm may involve to reduce the errors and refine the node positions. Localization algorithms can be categorized into two classes[3]

2.3.1 Ranging Algorithm based on:

- Received Signal Strength(RSS)
- Time Difference of Arrival (TDOA)
- Time of Arrival(TOA)
- Angle of Arrival (AOA)

2.3.1.1Received Signal Strength:-

Radio signal energy can be seen as an electromagnetic wave. These waves' strength decreases as moves forward. This signal strength is decreasing as inverse proportional to the square of the travelled distance. If d

is the travelled distance then signal strength is given by[4]

$$\text{Signal Strength} \propto 1/d^2$$

We can consider the RSS of low frequency, RF or other signals. Wireless sensors nodes communicate with neighbouring sensors, so the signal strength of the radio can be calculated by each receiver during normal data communication without requiring additional bandwidth or energy requirements. Even with adjacent stationary sensor nodes, RSS will vary to some degree due to noise. The noise affecting the RSS is not constant; it varies with time as well as environmental conditions. Finally, radio signals can vary significantly in both transmission strength and receptivity, particularly in cheap, low-power radio devices. The RSS directly varies with the inverse power of distance. A constant level of noise can result in increasing error rates when signal strength is used to estimate distance.The received signal strength method uses the relationship of radio frequency signal as a function of distance. From this relationship a mathematical propagation model can be derived. From detailed studies of the RF signal propagation characteristics, the main disadvantage of this method is that the propagation characteristics of radio signals can vary with changes in the surrounding environment temperature, humidity, pressure, areas such as: rural, urban.[3]

2.3.1.2 Time Difference of Arrival:-

There is a category of localization algorithms utilizing TDOA measurements of the transmitter's signal at a number of receivers with known location formation to estimate the location of the transmitter. TDOA used to estimate the location of unlocalized nodes. In this technique the difference of arrival radio and ultrasound signal at different sensor nodes is used for target location estimation.

2.3.1.3 Time of Arrival:-

Time of arrival (also time of flight) is the amount of time a signal takes to propagate from transmitter to receiver. Because the signal propagation rate is constant and the travel time of a signalcan be used to directly calculate distance. Multiple measurements can be combined with trilateration to find a location. This is the technique used by GPS. Systems which use TOA generally require a complicated synchronization mechanism to maintain a reliable source of time for sensors. Time of arrival measurements are also most accurate when the signal has distinct time-dependent features on the scale of interest [3]. It is used to find the location of un-localized node. This localization calculates the speed of wavelength and the time of radio signals traversed between anchor node and un-localized node [5].

2.3.1.4 Angel of Arrival:-

Angle of arrival is the angle from which a signal arrives at a receiver.AOA is usually determined by measuring the time difference of arrival between multiple antennas in a sensor array. In other receivers, it is determined by an array of highly directional sensors the angle can be determined by which sensor received the signal. AOA is usually used with triangulation to find the location relative to two anchor transmitters. The angle of arrival at a receiving station can be determined by the use of a directional antenna, or by differential time of arrival at an array of antennas with known location.Alternatively, the AOA at two receiving stations of known location establishes the position of the transmitter. The use of multiple receivers to locate a transmitter is known as multi -lateration.[6]

2.3.2 Range-free algorithms:

Ranging-free localization algorithms require high performance hardware. The range-free localization algorithms include,

- Centroid algorithm
- DV-Hop algorithm
- APIT algorithm

2.3.2.1 Centroid Algorithm:-

In mathematics and physics, the centroid is geometric centre of a two-dimensional region. Formally, the centroid of a plane figure or two-dimensional shape is the arithmetic mean ("average") position of all the points in the shape. The definition extends to any object in n-dimensional space: its centroid is the mean position of all the points in all of the coordinate directions. While in geometry the term barycentre is a synonym for "centroid", in physics "barycentre" may also mean the physical centre of mass or the centre of gravity depending on the context. The centre of mass is the arithmetic mean of all points weighted by the local density or specific weight. If a physical object has uniform density, then its centre of mass is the same as the centroid of its shape. The geometric centroid of a convex object always lies in the object. A non-convex object might have a centroid that is outside the figure itself. If the centroid is defined, it is a fixed point of all isometrics in its symmetry group. In particular, the geometric centroid of an object lies in the intersection of all its hyper planes of symmetry. The centroid of many figures (regular polygon, regular polyhedron, cylinder,

rectangle, rhombus, circle, sphere, ellipse, ellipsoid, super ellipse, super ellipsoid, etc.) can be determined by this principle alone .In particular, the centroid of a parallelogram is the meeting point of its two diagonals. This is not true for other quadrilaterals. For the same reason, the centroid of an object with translational symmetry is undefined (or lies outside the enclosing space), because a translation has no fixed point [6].

The implementation of centroid algorithm contains below steps.

- All anchor nodes broadcast their location information and identity to all sensor nodes in their transmission range. All nodes listens the signal for a fixed time t and collect the location information from various anchor nodes.
- All un-localized nodes determine their position by forming a polygon and calculate the centroid from all positions of anchor nodes in their range by using the below formula,

Xest = (X1+ X2…..+ Xn) /n

Yest = (Y1+ Y2…..+ Yn) /n

Where (X1, Y1)… (Xn, Yn) are the anchor node's coordinates and (Xest, Yest) is estimated coordinates of the node. [4]

2.3.2.2 DV-HOP Algorithm:-

One of widely used range-free algorithms is DV-HOP, in which the real distance between unknown node and anchor nodes is replaced by the product of average one-hop distance and the minimal hop number from the unknown node to some specific anchor node, and then the unknown node's position can be inferred through triangulation algorithm or maximum likelihood estimators (MLE) But the traditional DV-HOP has two drawbacks replacing the real distance between the nodes with the hops introduces certain errors to the computation range-free DV-HOP algorithm does not need any additional range modules (cost-effective), and is little affected by environmental factor (in compassion with range-based localization algorithms). These characteristics make them suitable to WSNs of simple node, low cost and large scale. But, one drawback in traditional DV-HOP algorithm lies in that in first step, the beacons issued by anchor nodes will flood into the whole networks. The great communications overhead will consume huge power, which, greatly limit the network's lifetime.[6]

In DV-Hop algorithm, locations of unknown nodes are calculated through some anchor nodes (i.e. GPS nodes which know its locations). DV-Hop algorithm includes the following three steps:

1) Every anchor node broadcasts its information of location (coordinate) and values of hop counts, which ensures all anchor nodes can obtain coordinates of anchor nodes and minimum hop-count of every anchor node through the Internet.

2) Calculate the average distance-sum of single-hop node and broadcast it. Unknown node will receive hop-count distance of nearest anchor node.

3) Recalculate the linear form of distance formula and adopt least square method to estimate the locations of unknown nodes[7]

2.3.2.3 APIT Algorithm:-

In this, we describe our novel area-based range-free localization scheme, which we call APIT. APIT requires a heterogeneous network of sensing devices where a small percentage of these devices (percentages vary depending on network and node density) are equipped with high-powered transmitters and location information obtained via GPS or some other mechanism. We refer to these location-equipped devices as anchors. Using beacons from these anchors, APIT employs a novel approach to perform location estimation by isolating the environment into triangular regions between beaconing nodes. A node's presence inside or outside of these triangular regions allows a node to narrow down the area in which it can potentially reside. By utilizing combinations of anchor positions, the diameter of the estimated area in which a node resides can be reduced, to provide a good location estimate. The APIT algorithm can be broken down into four steps: 1)Beacon exchange, 2) PIT Testing, 3) APIT aggregation and 4) COG calculation. These steps are performed at individual nodes in a purely distributed fashion.[6]

3. Conclusion: - In this paper, WSN has many application in which sensor can collect data from particular location and process it. We studied the different range based and range free algorithm techniques. Among them range free techniques are better than range free because it is low cost and does not need any hardware.

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