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WSN: Localization Concepts and Techniques

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Abstract -- A WSN contains numerous number of sensor nodes. These nodes are interrelated to make a network. The nodes in the WSN configure a network that route the data across the network to primary location wherever it is analysed and used for a number of objectives. In today's era, WSNs are commonly used in a lot of application areas related to environment aspects and physical sensations such as medical, military, environmental and air pollution monitoring, traffic management, green house monitoring etc. There are number of applications where sensor networks require location awareness means nodes need to be localized, but it is very costly to mount a GPS receiver in a sensor node. The problem becomes huge if the network is very large. Hence, there should be some mechanism or scheme through which location of unknown sensor nodes can be known without the assistance of GPS or a few numbers of nodes having GPS known as localization. This paper presents localization concepts and techniques which are used to localize the sensor nodes.

Keywords: Context based image retrieval (CBIR), Feature extraction, Text based image retrieval (TBIR).

I.Introduction

WSNs contain a number of sensor nodes, closely arranged inside a physical phenomenon. The nodes in the WSN configure a network that routes the data throughout to primary location. Here it is analysed and consumed for distinct purposes. Localization is the procedure of discovering the location of nodes because data and information are worthless knowing their geographical locations. Many sensor nodes identify their locations due to extra hardware like GPS. These sensor nodes are called beacon or anchor nodes. However, it is not practical to mount every sensor node in a network with extra hardware like GPS due to high cost. Therefore, localization, a mechanism for autonomously discovering and establishing spatial correlations among sensor nodes, is of huge prominence in the development of WSNs [1].

II.Localization Concepts

Localization is assessed via communicating among unlocalized node and localized node to determine the geometrical placements or positions of sensor nodes. Location is assessed by the measures of distances and angles between sensor nodes. Five main concepts are used in localization:

(a) *Lateration*: when the location is assessed by measuring the distance between nodes is called lateration.
(b) *Angulation*: - when the location is assessed by measuring the angle between nodes is called angulation.
(c) *Trilateration*: - when a node's location is assessed via distance calculation from three nodes, called trilateration. In the concept of
trilateration, as shown in Figure 1, calculating intersection of three circles having centres A, B and C nodes provides a sole point which is the location of unlocalized node S.

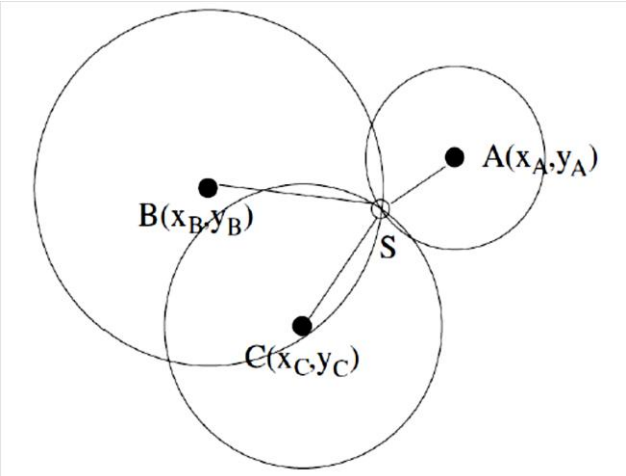

Figure 1: Trilateration [2]

(d) *Multilateration*:- In this concept, as shown in figure 2, more than three nodes A, B, C and D are used in location estimation of S.

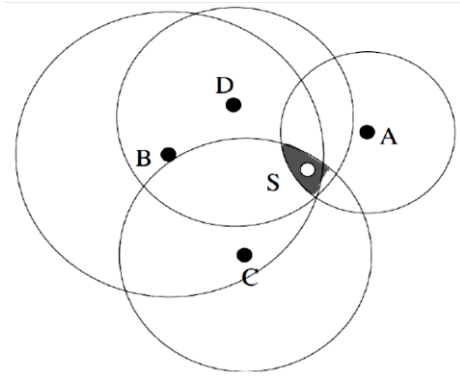

Figure 2: Multilateration [2]

(e) *Triangulation*:- In this mechanism, as in figure 3, as a minimum two angles αA and αB between two localized nodes A and B and an unlocalized node S are calculated to assess the location. Law of cosines and sines and trigonometric laws are used to calculate node position [3].

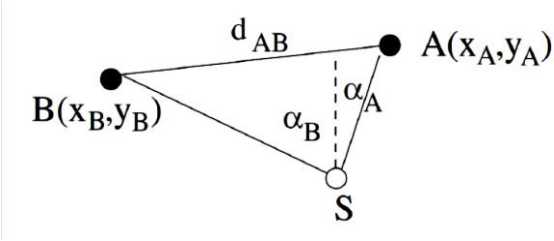

Figure 3: Multilateration [2]

III.Classification of Localization Techniques

Localization techniques can be grouped as anchor based and anchor free, centralized and distributed, stationary and mobile sensor nodes, range based and range free, and fine grained and coarse grained, GPS based and GPS free. These are explained as below **[4]:**

(a) *Anchor based and anchor free*: location of several nodes are well-known in this type of mechanism and locations of unlocalized nodes are assessed through these known nodes' locations. Anchor free mechanisms assess relative locations of nodes in place of absolute locations.

(b) *Centralized and distributed*: Centralized algorithms are developed to execute on central machines with extreme computing power. The sensor nodes gather environmental data and route it back to a primary location for further consideration. Then computed locations are conveyed reverse into the network. These algorithms solve the problems of computing shortcomings of a node. Distributed algorithms are developed to execute in the networks, using inter-node interaction and parallelism to counteract for the scarcity of centralized computational power and simultaneously to decrease the costly node-to-sink communication.

(c) *Stationary and mobile sensor nodes*: Stationary sensor nodes are static i.e. their position is fixed in the network while mobile sensor nodes are dynamic i.e. these nodes change their position with some moving speed and after a period of time in the network.

(d) *Coarse Grained and Fine Grained*: Coarse-grained based schemes for localization are where strength of received signal is not used but Fine-grained based localization schemes are where localization techniques employ characteristics strength of received signal.

(e) *GPS based and GPS free*: Localization accuracy is very extreme as every node has been installed a GPS receiver but these are very costly schemes. GPS free mechanisms compute the gap among the nodes respective to local network. These are not very expensive.

IV. Centralized Versus Distributed Localization Techniques

In centralized localization techniques, a centralized information architecture already present in several networks where such as environment monitoring, health monitoring and road traffic control and monitoring, the measured data of all the nodes are gathered in a central processor unit within a network. In this type of networks, a centralized localization scheme is suitable [5].

Distributed Localization techniques don't involve centralized computations. These techniques depend on all nodes calculating its location with only partial interactions with neighboring nodes.

V. Classification of Centralized Localization Techniques

Three main techniques are present for constructing centralized distance-based localization algorithms: stochastic optimization, linear programming and multidimensional scaling (MDS) approaches.

(a) *Stochastic Optimization*:- This technique implies an alternate specification and resolution of localization problem on the basis of distance by means combinatorial optimization tools as well as notions. The simulated annealing (SA) technique is the primary tool in this approach. This technique is a simplification of the Monte Carlo approach [5].
(b) *Semi-definite Programming (SDP)*:- It is developed from linear programming. It uses convex optimization to assess locations on the basis of connectivity limits having several nodes which are aware of their locations [6].
(c) *Multidimensional Scaling (MDS)*:- This technique can be employed in the network-based localization. The entire network is grouped into smaller clusters in this approach where neighboring clusters can share mutual sensors. Every cluster includes minimum of three anchors. The relative locations of sensors in each cluster is assessed by using MDS and local maps are build. After that the local maps are tacked collectively to configure a projected global map for the sensor network by employing mutual sensors among adjoining local maps. Then assessed locations of anchor nodes in projected global map are repeatedly associated with the actual locations of anchor nodes in the future to attain the last projected global map [5].

VI.Classification of Distributed Localization Techniques

Distributed localization techniques don't entail centralized computations, and depend on every individual node assessing its location with just partial interactions with adjoining nodes. The techniques could be categorized as range-based and range-free. Range-based techniques employ angle or distance estimation in location computations, where a range-free solution determined by information present in arriving messages [7].

A. Range Free methods

Range free algorithms consist neighborhood and Hop counting techniques. Range free techniques employ merely radio connectivity data for the calculation of location of node. These are less expensive techniques due to no demand of additional hardware. The results are inaccurate in these techniques. The various range-free methods are as follows:

(a) *DV Hop*: DV hop technique determines range among nodes by means of hop count. As a minimum, three anchor or beacon nodes disseminate coordinates along with hop count through sensor network. This information circulates within the network from neighbour to neighbour node. After a neighbour node accepts such type of information, the hop count is increased by one [8].
(b) *Hop Terrain*: This method works in two steps. Starting with the prime step, unlocalized node assesses its location from anchor node by the use of an average hop distance formula. Average hop distance is the distance among two nodes or total numbers of nodes or hops. It is called initial position estimation. In the second step, initial assessed location is disseminated to neighbour nodes. Neighbour nodes get initial assessed position with information regarding distance. Each node refines its location till final location is found by means of least square method [9].
(c) *Centroid System*: The centroid system employs grained localization algorithm on the basis of proximity. It employs numerous anchors. These anchors disseminate their locations as per coordinates. Once got information, all unlocalized nodes assess their locations [8].
(d) *Approximate Point in Triangulation (APIT)*: Beacon nodes obtain information regarding their location from transmitters or GPS in APIT scheme. Unlocalized node obtains information about location from intersecting triangles. The region is distributed into intersecting triangles [9].
(e) *Gradient Algorithm*: Multi-lateration is performed by an unlocalized node to obtain its location in gradient algorithm. This algorithm begins by an anchor or beacon node and supports unlocalized nodes to assess their locations using three anchors via multi-lateration [9].

B. Range based methods

Range-based methods are angle-estimate and distance-estimate-based techniques. These techniques are more suitable for localization. These techniques need additional hardware for Angle of Arrival (AoA) and Time Difference of Arrival (TDoA). These require Ultra Sound or Acoustic Modules for TDoA whereas Radio and Microphone arrays for AoA. Additional hardware used in AoA is costlier as compared to TDoA due to each node having a speaker and several microphones [10]. The various range-based methods are as follows:

(a) *Received Signal Strength Indication (RSSI):* Distance or gap between receiver and transmitter is assessed by computing strength of signals at the receiver end in the RSSI [2]. Moreover, transmission loss is computed, and it is transformed into distance estimation [9].

(b) *Angle of Arrival (AOA):* Location of unlocalized node possibly be assessed by means of an angle of two anchors' signals on which the signals of anchors are obtained by the unlocalized nodes [2]. The unlocalized nodes employ triangulation concept to assess the locations [9].

(c) *Time Difference of Arrival (TDOA):* The TDoA of radio and ultrasound signals is employed in this technique. Each node in the sensor network is mounted with speakers and microphones [12]. Beacon node transmits signals and wait for a certain amount of time.

(d) *Time of Arrival (TOA):* Time of radio signals and speed of wavelength transmitting among an anchor and an unlocalized node is computed to assess the location of unlocalized node in (TOA) [9].

VII.Conclusion

Today, WSNs are used in many application areas. In these application areas, locations of the sensor nodes are required for further processing of data. A lot of research had done in the field of WSN in which localization is the important issue. There are number of techniques which are available to determine the locations of these sensor nodes. This paper has provided the review of different categories of localization techniques and their sub types. Solving the localization problem in WSNs has proposed further new issues. The future direction of research in localization algorithms possibly is reducing localization errors and localization in mobile WSN. To reduce the localization errors, new algorithms can be proposed or existing algorithms can be refined.

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