International Journal of Scientific Research in Computer Science, Engineering and Information Technology
ISSN : 2456-3307 (www.ijsrcseit.com)
doi : https://doi.org/10.32628/CSEIT217391

Survey of Localizations Algorithms in Underwater Wireless Sensor Network

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Article Info
Volume 7, Issue 3
Page Number: 403-409

Publication Issue :
May-June-2021

Article History
Accepted : 25 May 2021
Published : 31 May 2021

ABSTRACT

The main objective of this research paper is to review and analyze the different existing localization algorithms techniques that are used to overcome the localization issue in the wireless sensor network. Underwater Wireless sensor networks consists up of small sensor nodes that are placed in huge quantity over a large water surface region to perform several tasks like sensing the data and communicate with other devices. Most of the applications of underwater wireless sensor networks like forest fire detection required the exact position of the sensing element. The main motive of the localization process is to localize the coordinates to the every node with unidentified location in the sensing area of underwater. In this paper, we have discussed various localization algorithms for localizing the sensor nodes like particle swarm optimization; bees optimization algorithm, bat algorithm, cuckoo optimization and butterfly optimization algorithm etc. are reviewed. The detail analysis of these techniques in terms of localization error, computation time and amount of localized nodes has been discussed in this paper.

Keywords: Localization, Range free, Survey, Wireless sensor network, Mobile anchor, Vehicles

Abbreviation- UWSNs- Underwater Wireless sensor network, **ASV** - Autonomous Surface Vehicles
SLMP- Simultaneous Localization and Mapping, **TDOA**- In time-difference-of-arrival

I. INTRODUCTION

In underwater wireless sensor networks, real-time localization and coordinate-based services are required that are accurate, low cost, energy efficient and reliable. Wireless Sensor Networks (WSNs) mainly occupied with many applications, such as natural resources investigation, targets tracking, unapproachable places monitoring and so forth. In these applications, the information is collected and transferred by the sensor nodes. Various applications request the location information from these sensor nodes. Moreover, the location information is also expandable in geographic routing protocols and clustering. All these mentioned above different localization algorithms become one of the most important issues in WSNs researches. Thus, locations of different sensor nodes are important for operations in WSNs. The process localization in WSNs has been intensively studied in some of last years, with most of these research state on the condition that only a few proportion of sensor nodes, called anchor nodes, know their exact positions through GPS devices or manual configuration. Other sensor nodes known as dumb node estimate their distances to anchor nodes and calculate positions with multi-lateration techniques. These methods provide acceptable level of accuracy with a small proportion of anchor nodes in WSN knowledge

The problems encountered by WSN are localization, routing, network topologies, storage capability etc. Localization in UWSNs is a process where the actual place of all the sensors is computed in bi-dimensional (2D) area. There are several issues in localization such self-localization of sensor node, node failure, and minimum location error of unknown nodes. Range is another issue for the deployment of huge amount of sensor nodes in underwater and these nodes are tightly reserved in terms of energy and storage capacities. There are several issues in routing such as restricted energy capacity, finding optimum path, coverage rate, delay, synchronization, intrusion finding of sinkhole attack, and limited time of nodes, etc. The primary objective of this paper is to determine the location of the sensor nodes inside surface of the water. Node localization process can be classified into two categories: range based localization and range free localization. The former method uses the measured distance/angle to estimate the location. In addition, the latter method uses the connectivity or pattern matching method to estimate the location.

II. REVIEW OF LITERATURE

1) "**Scalable Localization with Mobility Prediction for Underwater Sensor Networks**"- In this paper, authors have presented SLMP, a new localization method with mobility prediction, and it is for large-scale underwater sensor networks. In SLMP, anchor nodes perform linear prediction by taking advantages of the inherent temporal correlation of underwater mobility pattern. And remaining ordinary sensor node predicts its location by utilizing the spatial correlation of underwater object mobility pattern, weighted-averaging its received motilities from other nodes. The simulation results of this shows that SLMP can greatly reduce the communication cost while maintaining a relatively high localization coverage and localization accuracy.

2) "**AUV-Aided Localization for Underwater Sensor Networks**"- In this paper a localization scheme for underwater acoustic sensor networks (UWSN) discussed that does not require a priori mutual synchronization between sensors nodes. An autonomous underwater vehicle (AUV) aids in localizing the sensor nodes that are inside of underwater surface while roaming across the underwater sensor field. The objectives of this paper are to describe how to localize nodes using AUV. The given localization success improves as the duration of the AUV localization process increases. In addition, they have mentioned investigated localization using two methods, bounding-box and triangulation. The former achieves a higher localization ratio but with a higher error. In certain scenarios, they achieved 100% nodes localized with 3% error.

3) "**Localization for Large-Scale Underwater Sensor Networks**"- In this paper, authors conveyed the localization problem in large-scale of underwater

sensor networks. The broad aqueous environments, the node mobility pattern, and the large network scale all pose new challenges, and most current localization schemes are not applicable. Authors proposed a hierarchical approach, which divides the whole localization process into two child-processes: anchor node localization and ordinary node localization. Many existing localization algorithm can be used in the former. For the given ordinary sensor node localization process, they proposed a distributed localization scheme which novelty integrates a 3-dimensional Euclidean distance estimation method with a recursive location estimation method.

4) **"Underwater Acoustic Source localization Strategy by a Group of Autonomous Surface Vehicles** "-In this paper, a general two stages localization algorithm is given known as target-search algorithm and target-drive algorithm. A target-search algorithm is based on how to search or detect the acoustic signal whereas a target-drive algorithm is used to drive the ASVs to search the target. Simulations for the results are performed to illustrate the working principle of the proposed localization strategy. In the future, a more feasible simulation considering the actual kinematic and dynamic of the ASV will be considered.
5) **"Preliminary Results on Three Dimensional Localization of Underwater Acoustic Sources**"- This paper presented a method of three dimensional underwater-acoustic source localization method. A specific configuration of four hydrophones was given to acquire acoustic signal transmitted from acoustic sources. The received acoustic signals were used to acquire TDOA and to predict the source location. Because of the specific configuration, analytic solution can obtained for different source locations. A primary result of source localization was shown as basin test. As a future direction, different filtering methods such as Kalman filter can be used to estimate acoustic source locations using underwater vehicle equipped with hydrophones. Moreover, both range and bearing information may be obtained through synchronous clock between transmitter and receiver for more accurate localization results.
6) **"Asynchronous Localization with Mobility Prediction for Underwater Acoustic Sensor Networks**"- This paper investigated the localization problem for UWSNs under clock a synchronization and node mobility constraints. Mainly, a hybrid architecture that includes AUVs, active and passive sensor nodes is projected. It constructs the relationship between propagation delay and position, and then a mobility prediction strategy is given to estimate the future positions of AUV and remaining sensor nodes. With the process timestamp measurements, an asynchronous localization algorithm with mobility prediction is given to determine the locations of active and passive sensor nodes, where iterative least squares estimators are carried out to solve the optimization problems. However, the convergence analysis for the proposed localization algorithm are also given. Simulation results show that the localization accuracy in this paper can be modified by comparing with the synchronous localization algorithms.
7) "**Cooperative Localization for Underwater Vehicles**"- This paper proposed an algorithm for distributed acoustic navigation for Autonomous Underwater Vehicles (AUVs). Whereas typical AUV navigation systems uses the pre-occupied arrays of static transponders, this work seeks to create a fully mobile network of AUVs that perform acoustic ranging and data exchange with one another to gain cooperative positioning for extended duration missions over large water surface areas. This algorithm elaborate possible

solution for the AUV path based on dead reckoning and range-only measurements provided by acoustic modems that are built on each vehicle, and chooses the path via minimization of a cost function based on these constraints. The resulting algorithm is more efficient, meets the strict bandwidth requirements of available AUV modems, and has potential to develop the networks of large numbers of vehicles. The method has undergone wide experimentation, and results from three different scenarios are reported in this paper, each of which utilizes MIT SCOUT Autonomous Surface Craft (ASC) as convenient platforms for testing. In the first experiment, they utilized three ASCs, each equipped with a Woods Hole acoustic modem, as surrogates for AUVs.

III.DIFFERENT LOCALIZATION MODELS

1) Distance calculation between dumb node and anchor node- Anchor node or vessel node sends the message in a predefined format. That message format contains the location (x, y, z coordinate), time of message creation, and message itself. If any beacon node is within the range of that anchor node, then that node receives that message and store in the memory area. Now using the below mentioned distance formula, dumb node can calculate their distance from that of anchor node.

$$D = \sqrt{(dx - x)^2 - (dy - y^2)} \quad (1)$$

where, D = distance calculated between anchor node and dumb node, x = X-coordinate of anchor node, dx = X-coordinate of dumb node, y = Y-coordinate of anchor node, dy = Y- coordinate of dumb node.

Equation of the circle i centered at x and y

$$(x - x_i)^2 + (y - y_i)^2 = R^2 \quad (2)$$

where, x_i and y_i is the location of the node, and R_i is the distance from anchor location to node location.

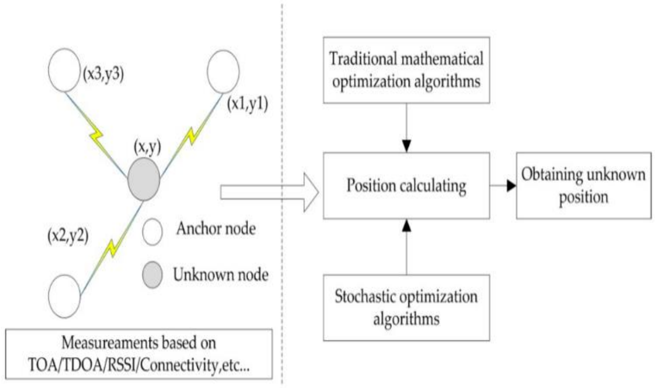

Figure 1. Localization Process Overview

2) Anchor free localization

SCAN-Let the boundary is of the rectangular shape. The anchor node will start from a coordinate at left bottom corner and then after it will move in the horizontal direction and the shift will be according to the range. In every shifted position, it will send the message about its location information. When it reaches nearer to the boundary, the direction of movement will shift on the axis perpendicular to previous axis. The bacon node, which is in the range of the anchor node, will accept the message and using time of arrival, it will calculate the distance of its own location from the anchor node.

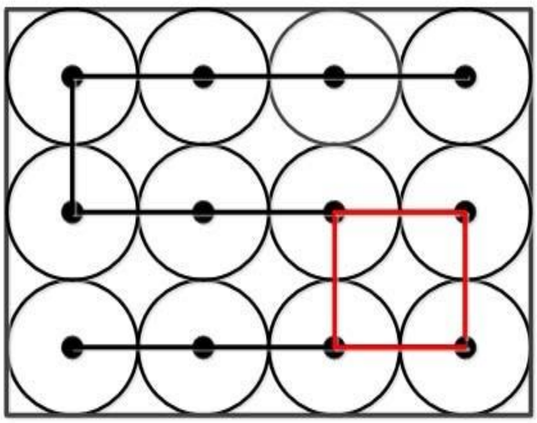

Figure 2. Vessel node movement in anchor free during localization

3) Distributed Positioning Localization- The distribution positioning localization method allows each sensor node to locate separately or nodes are free to locate with the help of such neighbourhood distance, anchor position, and connectivity data and then send all these data separately to the reference or anchor node. On the other hand, instead of being placed in one central entity, the function of location finding is distributed to the sensors themselves in the distributed localization algorithm. In a distributed network, different sensor nodes communicate through peer-to-peer (P2P).

4) Infrastructure based localization- Infrastructure-based localization method using underwater wireless sensor network (UWSN) is addressed. A localization using the UWSN is necessary to choose the usage of underwater applications, but it is very difficult to establish the UWSN due to the restrictions of water. to extend the usage of UWSN at the infrastructure. It uses a sophisticated UWSN localization method using the Received Signal Strength Indicator (RSSI) of the electromagnetic waves. During the electromagnetic waves propagating in underwater, there arises a lot of attenuation according to the distance, while the attenuation shows uniformity according to the distance. Using these characteristics, the localization system in underwater infrastructure is proposed and the experimental results show the effectiveness

5) Hop Based Localization- The Hop based on localization algorithm is a distributed range-free localization algorithm which is based on the distance vector routing mechanism protocol. The given principle is to calculate the distances between anchor nodes and dumb nodes by multiplying the average hop distance in UWSNs by the hop count of the anchor nodes. Then, the position information of dumb nodes is obtained through trilateration, triangulation, and mul-tilateration, thus realizing localization.

6) Area Localization Scheme- For large area of wireless sensor networks, identifying the exact location of every sensor nodes is not so much feasible and the cost may be very high. A due estimate of the sensors' locations is usually sufficient for many applications. In this localization scheme , we propose an efficient Area Localization Scheme (ALS) for underwater sensor networks. This scheme tries to find out the position of every sensor within a specific area rather than its exact location. The granularity of the areas estimated for each node can be easily adjusted by varying system parameters. All the complex calculations are done by the powerful sinks instead of the sensors. This reduces the energy consumed by the sensors and helps to extend the lifetime of the sensor nodes.

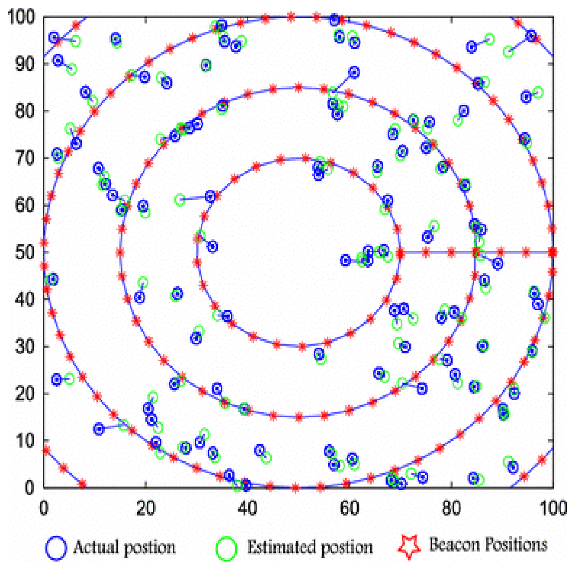

Figure 3. Area Based Localization

IV. COMPARISON

Schemes	Range Based	Accuracy	Distributed	Placement of vessel node	% of anchor node
Infrastructure based positioning	Range Based, ToA	Acccurate:1 to 10m for 3km to	Distributed	At the corners of a square grid	small

systems		4km			
Distributed positioning	Range based , TDoA	Not Accurate 0.5* (Radio Range)	Distributed	Distributed randomly	High
Hop Based	Range Free	Not Accurate 0.5* (Radio Range)	Distributed	Only for anchor	Low
Centroid based localization	Range Free	Not Accurate 0.5* (Radio Range)	Distributed	In a grid structure	High
ALS	Range free	Not Accurate 0.5* (Radio Range) to 1* (Radio Range)	Centralized	At the corners of a square grid	Low
APIT	Range free	Accurate	Distributed as well Centralized	Randomly Distributed	High
Signal Processing Based	Range based RSSI	Accurate, But only good for small areas	Centralized	No anchor nodes	N/A

V. CONCLUSION

In this paper we discussed the localization of terrestrial sensor network. It mainly highlights the different localization scheme that can be applied on underwater wireless sensor network. All of the schemes are broadly divided into two parts of range based or range free localization process. This paper presents a review of UWSNs, underwater localization, localization techniques, and the existing algorithms in the underwater surface. The paper mainly focused on the algorithms those are recently used in underwater localization. Localization for UWSN is an important problem that attracts considerable interest from scientists working on localization underwater. In this paper, the unique characteristics of UWSN and underwater localization are explained in detail. Furthermore, the paper presented the localization basics, localization architecture, and the techniques used for underwater localization.

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Cite this article as :

Sitanshu Kumar, Dr. Sunil Rathod, "Survey of Localizations Algorithms in Underwater Wireless Sensor Network ", International Journal of Scientific Research in Computer Science, Engineering and Information Technology (IJSRCSEIT), ISSN : 2456-3307, Volume 7 Issue 3, pp. 403-409, May-June 2021.
Available at
doi : https://doi.org/10.32628/CSEIT217391
Journal URL : https://ijsrcseit.com/CSEIT217391