A Survey on Underwater Localization,Localization Techniques and Its Algorithms

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Abstract. Underwater localization are an importantpart of underwater sensor networks (USNs). USNs attracted significant attention, they are widely used for many applications, such as tsunami before the reaching inhabited areas, pollution monitoring, civilian and military applicationsOcean resource exploration, USNs which are mounted on the ocean bottom can detect earth quakes and Ocean monitoring. The variable speed of sound and the non-negligible node mobility due to water currents create a unique set of challenges for localization in UWSNs. This present a comprehensive survey of different techniques which are employed in USNs. This survey paper mainly focus on USNs, Localization techniques and its algorithms.

1.Introduction

During the last years, we have seen a development in Underwater Wireless Sensor Networks (UWSNs). There are many applications but important one of them is, they can improve ocean exploration and also accomplish the demand of a multitude in underwaterwhich include, warning system i-e earth quake and tsunami, navigation, collection of data, military surveillance in underwater, ecological application i-e biological water quality, pollution controllinge.g. In offshore engineering side the sensors are able to measure parameters such as base strength and mooring tension to supervise the structural health for deep water systems [1]. Another technology which provides new chance in underwater acoustic sensors network which improve our understanding about these problems such as variation in the population in of coral reefs, change of climate and life of ocean animal's. In [2], the authors propose a new scheme call 3-DUL which initially use just three anchor nodes like buoys on surface that generate his global position information in three directions (3D).3DUL uses a two-step process. At first step, a sensor node that's have unknown location which find the distances to itsneighboring anchors nodes. In second step, it uses these pairwise distances and depth information to protrude the anchors onto its horizontal plan and make a virtual geometric shape. If the shape is racy, the sensor node situate itself by dynamic trilateration and becomes an anchor node. Then, it will serve other nodes. This process is dynamically iterates in all 3D topology to localize more nodes as achievable. Its algorithm allows the UASNs to adjust to the dynamic nature of water environment [3]. For this reason ocean controlling process is used which can collect data from ocean and the surrounding area and sending this data to on-shore center through satellite or using cables. Radio signals in underwater can only traveling to a short area because radio signal rapidlyattenuate in water and optical signals disperse andcannot travel in inapplicable environment. Compare to radio and optical signals, acoustic signal are scatter less. Even the bandwidth of acoustic is depress in underwater so as result the data rates will be low. In addition, acoustic channel have low link quality [4],it's due to the time-changing of the medium and multi-path generation. Because of these challenges the UASNs is an energy limited as WSN. Localization is central task which is uses for different purposes just like data tagging, nodes tracking, coordinates motion of nodes in groups, to find the location of a target. In [5] Underwater

Sensor Networks (USNs) can meliorate ocean exploration, permit a list of new applications that are now not possible, including: collection of oceanographic data, ecological applications i-e water quality and biological monitoring, safety i-e. Disaster prevention, seismic and tsunami, military underwater surveillance, industrial etc. In [6], for navy defense, USNs can cater instant deployment capability and increment coverage in surveillance applications of coastal regions.

2. Technologies or Techniques used for UASNs Localizations

GPS based localization scheme in terrestrial WSNs, which is unable to apply directly to UASNs due to some reasons such as the high frequency GPS which attenuate rapidly in water and cannot reach to the nodes below the surface of water. Another reason GPS-less localization schemes generally introduce high communication overhead [7]. There are many location techniques some of them we have categorize as centralized and distributed localization techniques. Further we divided centralized and distributed into i-e. Estimated and Prediction base localization.

2.1. Centralized Localization Technique

Calculate the location of each sensor node in a command center or sink, and the sensor node do not know their location unless the sink or center explicitly sends this information. May be these technique localize nodes at the end of the mission i-e post processing period; or may periodically collect information to find sensor nodes. In [8], centralized algorithms mean that a central sink exists, which collects all the necessary information and determines the locations for the sensors in a centralized way.

2.1.1. Estimated base localization

They are further divided into sub parts such as

2.1.1.1. Hyperbola based localization (HL) Technique

In oceanographic system, localization of a sound source, i- e mammals can be detected by a set of hydrophones such as sensors with known locations [9], using the Hyperbola based localization scheme. Using HL, sensor node sends a long-range signals around 1km to the anchor node, and location are estimated by a centralized node.

2.1.1.2. Motion aware self-localization (MASL) Technique

Due to propagation delays, collecting the number of distance estimates under the water which required for localization, it may be take long time which consequently increase the possibility of obsolete information. MASL is specially used to address the inaccuracies in the distance estimates and provide a good localization. In MASL technique, the underwater node can collect distance estimate between itself and its neighbor'snodes. In [10],authors propose a model, as the ocean current as layers that have an equal thickness and a variable speed. The sensor nodes are moving with those currents produced.

2.1.1.3. Three dimensional multi-power area localization scheme (3D-MALS)

Here 3D-MALS combines two ideas first one is, anchors with variable transmission power level [11], and the second is anchors with vertical mobility of buoys , house mechanical unit which is working as an elevator for transceivers in underwater they are called Detachable Elevator Transceiver (DETs). DET can broadcast their set of GPS-driven coordinates at different power levels and descend underwater. Those nodes which are un-localized can collect position of mobile anchor and respective lowestpower levels and then send these position information to sink node.

2.1.1.4. Area base localization scheme (ALS)

In [12], ALS is range-free, centralized, localization technique for underwater sensor networks. Using ALS, anchors divide the region into non-overlapping areas by making changes in the power levels. An underwater sensor keeps a list of anchors and its corresponding power levels. Nodes

sends this information to the sink and the sink determines the area in which the sensor resides in. To know more about ALS refer to [13], a central server provide the position estimation of sensor after providing all of the areas, that it resides in. On the other hand, USP is a 3D localization scheme with inner position granularity than ALS. Only a seed node are used to broadcast a message to gain information from its neighbor's nodes, this is again shared with its neighboring nodes. If only seed nodes carry out to discover other nodes positions, other nodes in the network do not needto expend energy on broadcasting messages. Different algorithms for selecting further seed nodes are Farthest/Farthest Algorithm, Farthest/Nearest Algorithm, Nearest/Farthest Algorithm, Nearest/Nearest Algorithm, for detail refer to [14].

2.2. Prediction Base localization Scheme

2.2.1. Collaborative localization (CL)

The author's proposed CL scheme in [15], they consider a mobile UASN process where underwater sensor nodes are responsible to collect information from oceans depth and carrying these information to the water surface. In this architecture the authors used two types of underwater nodes one is profilers and the second is followers. These both types of nodes descend underwater however profilers descend ahead. The distance between the profilers and the followers are measured periodically usingToA technique.

2.2.2. Distributed localization technique

In Distribution localization technique it allow each sensor node to do localization individually, collect data i-e distance to neighbors or anchors, position of anchor, information of connection and then send all these information individually to the reference node.

2.3. Estimated Base localization Schemes

2.3.1. AUV-Aided Localization (AAL)

The authors proposed the AAL scheme in [16],using another technique a hybrid, three-dimensional UASN in which the underwater sensor nodes will be in static position and AUV transverse inside UASN region. See Fig. 1.
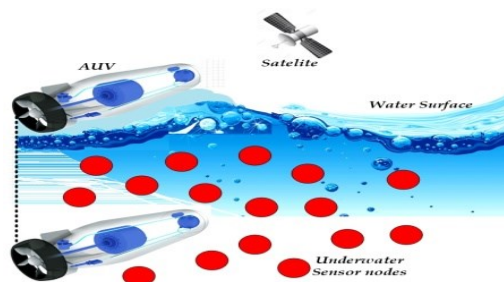

Fig.1. Localization of AAL

To use the dead-reckoning technique the AUV can be able to attain its location underwater. During the first cycle, AUV can broadcast a wake-p message from different point on its route they are going periodically. It is occurring when the nodes underwater receive this message, then they start localization process with sending a request packet to the AUV, then AUV will replies with a response pocket to the nodes.AUVs emit Omni-directional beacons refer to [17]. When AUV passes near bya sensor nodes at time t1, node will receive the beacon message which is used to measure the distance d1 between AUV and the corresponding node. Similarly at time t2, the distance d2 can be measured using TOA technique as shown in Fig. 2. To obtain the coordinate of a sensor node, the coordinates of the AUV at two time instants are necessary. Which based on triangulation, the position of the node is decided. Our approach is on difference of time.
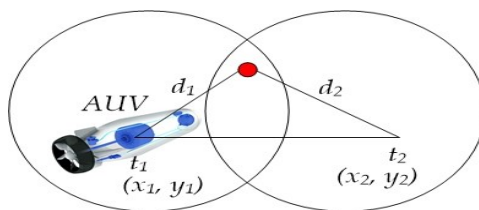
Fig. 2. AUV-aided Localization in Omni-direction.

2.3.2. Silent Localization

In [18], the authors explain positioning process which consists of three steps. At first step AUV sends a wakeup signal and it comes into the sensing area. In response the sensors send a request packet when they received the wakeup massage form AUV. Finally AUV replies a response packet which contains the coordinates of that node. For this process each sensor node required to communicate with AUV at least once. This type of approach is called silent localization algorithm.

2.3.3. Dive and Rise localization (DNRL)

To describe DNRL in better way refer to [19]. It is a distributed, estimated-based localizationalgorithm, DNRL uses mobile anchor node to process localization of underwater nodes, and we call these anchors DNR localization. Using the hydraulic principles similar to the profiling floats, DNR are able to descend and ascend up to certain depth. When DNRL are coming to the water surface it uses GPS receivers and collect their coordinates from the GPS. DNR again descend until a pre-defined depth, and during descending period they announce their coordinates at several positions. At first round, mobile anchors ascend to the surface to receive the updated coordinates from GPS. Then at second round they periodically descend

2.3.4. ProxyLocalization (PL)

Poxy localization is a technique which uses the DNRL technique to localize the upper area of a network. DNR beacons descend up to the middle of three dimensional USN. After that, a localized nodes work as a location proxies for those nodes which arefloating at deeper levels. Location proxies announce its own coordinates for further localization. Nodes which are Non-localized may use coordinates of the proxies using alteration process and localize ourselves. The non-localized underwater node will use the hop count algorithm to choose the reliable proxies among all of them. Packet format for PL is shown in Fig. 3.
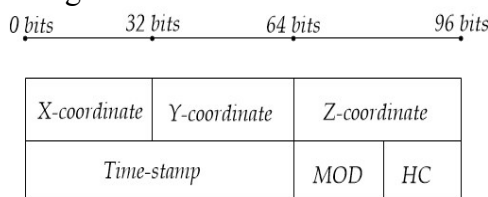

Fig. 3. Format of Location packets for Proxy.

2.3.5. Localization with Directional Beacons (LDB)

Basically LDB is proposed for a hybrid, 3-dimensional UASN. In this algorithm stationary underwater nodes are localized through AUV similar to the AAL algorithm. When AUV come to the surface of water it receives its coordinates from the GPS, again it dives in water to do dead-reckoning up to certain depth for self-localization in underwater. AUV travels above on thearea of operation. AUV uses a directional acoustic transceiver to disseminate its coordinates and also the angle of the transceivers beam. Sensor node use angle information to map the AUV coordinates to itself and with same horizontal plane. See Fig. 4. a) AUV with directional beam in the LDB scheme and Fig. 4. b) sensor localization in LDB.
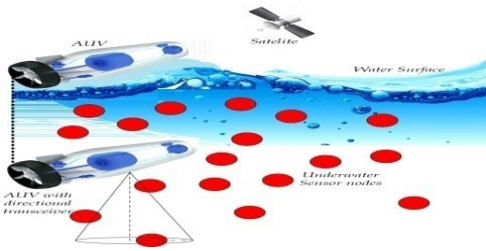
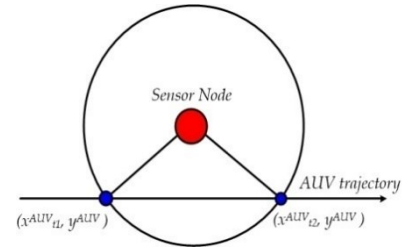Fig. 4. (a). AUV with directional beam in LDB algorithm,

Fig. 4. (b). Localization of Sensors in LDB Scheme

2.3.6. Multi-Stage Localization (MSL)

In MSL distance measurements and coordinates are used by an un-localized from three non-coplanar nodes which may be a localized underwater node or a DNR beacons. One drawback of MSL is, it have a high communication overhead and it is due to iterative localization. Because of this drawback of MSL, DNRL is more energy-efficient than MSL. Furthermore, in MSL, localized underwater nodes gives their estimated locations, which already have some estimation errors. At the nodes error accumulates which uses coordinates of localized underwater nodes alternatively of the coordinates of an anchor nodes.

2.3.7. Underwater positioning system (UPS)

UPS is a system for the tracking and navigation of underwater vehicles using acoustic distance or direction measurements, and subsequent triangulation. In [20], the authors introduce UPS, which is theProlongation of the terrestrial WSN localization. UPS on the basis of TDoA-based localization for stationary UASNs. It uses four anchors which Consecutive send beacon. Among these anchors, one anchors work as a master (Head) anchor and its function is tooriginate the localization process. For example the master anchor are selected as Anchor "A" of Fig 5. When ''A'' sends the beacon signal, Anchor ''B'' and Sensor node S receive this signal. Anchor B in response replies to A and send the time difference between the arrival time of the Anchor as beacon signal and the transmission time of the beacon signal. Anchor B, C and D following the same procedure.
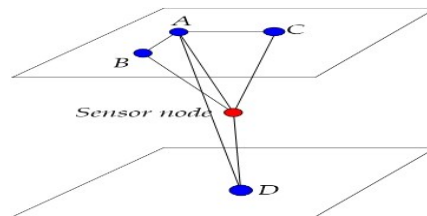

Fig. 5. Underwater Positioning system (UPS) using four

2.3.8. Wide Coverage Positioning (WPS)

WPS is scheme which trust on an infrastructure that using 5 reference nodes but they only employ beaconing from the fifth reference node when it is required.The authors propose a UPS technique which may not be able to localize all of the sensor nodes in the area of four anchor nodes. It demonstrate that the sensor nodes which is reside close to the anchor nodes will require five anchors nodes. If WPS uses four anchors nodes whenever unique localization is attainable it will using four anchors nodes i-e UPS(4)), if WPS uses five anchors (UPS(5). UPS (4) and UPS (5) are used combinely to solve the communication overhead for the nodes that are localizable with four anchors.

2.4. Prediction Base Scheme

2.4.1. Scalable Localization with Mobility Prediction (SLMP)

In SLMP, anchor node estimate location usingtheir previous coordinates and patterns of mobility. Anchor node sporadically check validity of pattern. If model isnot valid, anchor activate updates. Coordinates received from GPS by surface buoys send to anchor nodes. Anchor node when predict

its location, uses surface buoyscoordinates and distance to buoys usinglateration to measureits location. In [21], the algorithms are classified into Range-based and Range-free.

2.4.2. Range-Based Algorithm

Range-based algorithm is an algorithm which measure measure the distance, precise estimation of distance or Angel measurement are made to estimate the algorithms used for, TDoA, ToA and AoA. RSSI is not too much commodious, due to its limitations such as, time-varying, which is rarely selected in UASNs. TDoA utilizes TDoA. Actually it is time difference between different transmission mediums, or the beacons coming from different reference nodes utilizes to measure distance between two objects and ToA is the time of arrival used to measure distance**.**

2.4.3. Range-Free Algorithm

In order to use range-free localization, we don't need to use range or bearing information, it provide a coarse estimate of a nodes location. Range-free algorithm are foster classified into hop count-based algorithm and centroid algorithm.

2.4.3.1. Hopcount-based Algorithms

Using hopcount-based algorithm, anchor nodes are placed at the corners or along the boundaries of square grid. Three methods are DV-Hope, DHL and robust positioning. The DV-Hope use average hope distance estimate and counted number of hops to calculate the distance to anchor. DHL, they can uses density awareness to estimate distance dynamically and Robust positioning algorithm are used to increase DV-Hop.

2.4.3.2. Centroid Algorithm

It is a range free proximity-based and coarse-grained localization method. The disadvantage of centroid localization algorithm lies in its high location error because of centroid equation; Where X, Y are the estimated location of receiver.

$$Xen, Yen = (\frac{X1+X2+X3+\cdots Xn}{n}, \frac{Y1+Y2+Y3\ldots+Yn}{n})$$

3. Conclusion

This present the underwater localization, architecture of underwater localization, localization techniques and algorithm of underwater localization. Basically localization is used for both terrestrial sensor networks and underwater acoustic sensor networks (UASNs). In UASNs localization is specially used for tracking underwater nodes, to collect the tag data, for coordination of different sensor nodes in a group and detection of target. We present a comprehensive survey on underwater techniques and challenges to underwater localization. We have classified these techniques on the basis of its characteristics such as estimated base localization and prediction base localization. We have divided estimated and prediction base localization into sub categories i-e Centralized localization technique and Distributed localization techniques. All the techniques discussed above manifest a good performance in simulations they are evaluated under the same condition because some techniques required less reference nodes which may limits the deployment area of UASNs and some required many reference nodes which may be very costly for UASNs. For the best of this survey we also included the algorithms which are classified into Range-based and Range-free.

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