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LOS Based Link Classification for UWSN Using Binary Evalution Theorm

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Abstract: In this study, we present a novel frame work for on-demand localization for autonomous deployment in UWSN to find the location and position of the sensor node with minimal error rate, based on the communication link types from the anchor nodes to sensor nodes underwater sensor networks contain anchor nodes and sensor nodes or initiator nodes which initiates the request in order to find its own position with the help of anchor nodes. These nodes listen to the broadcast message localize themselves without consuming additional resources. This proposed research classifies the links LOS (Line Of Sight), OLOS (Object based LOS) and SLOS (Sea based LOS) respectively, based on binary evaluation theorem using propagation delay, absorption loss and reflection loss as a key factor. Location estimation of sensor node can be computed whenever there is a change in network topology. Position accuracy can be achieved by classifying the links types and compute the values of selected links. This study focuses on the classification of the links and how it can be analyzed to produce location accuracy in UWSN.

Key words: Utonomous, sensor nodes, LOS, propagation, accuracy

INTRODUCTION

In the world almost over 70% of the area is covered with water, so more research activities are under gone on underwater systems for various applications like data collections, location identification and environment monitoring. This raises the need for an effective way to collect data and monitor the underwater environment. Developments in Wireless Sensor Networks (WSNs) leads to the enhancement of Underwater Wireless Sensor Networks (UWSNs) which have become an emerging and enabling technology to enhance applications such as resource exploration, disaster prevention, pollution detection and monitoring, along with military surveillance in underwater. The doppler effect is more important in acoustic communications (Kantarci *et al*., 2011).

In node deployment (Kantarci *et al*., 2011) stage selecting the preferred node deployment algorithm among the three node deployment algorithms based on the requirement. Once the deployment is completed we need to initiate the localization process. Localization process can be initiated with the help of AUVs. Localization is done by combination of both LBL and SBL based localization techniques (Han *et al*., 2013). In the LBL technique acoustic transponders are deployed on either the seafloor around the area of operation to initiate the localization process whereas in SBL technique, a device need to follow the underwater equipment and uses a short-range emitter to enable localization process the device may be AUVs.

Communication in under water is only possible with the use of acoustic communication. While finding the location GPS is not an efficient technique in underwater environment. After the communication has been established localization protocol has to be chosen, major classification are distributed localization protocol and centralized localization protocol further they are classified in to various types. During localization process range differences have calculated with the help of ranging methods or ranging techniques. Using the range difference apply it in trilateral equations we can able to estimate position on location of the particular sensor node with (x, y, z) coordinates.

Node deployment plays a vital role for underwater acoustic sensor networks which provides network services like network topology control, routing and boundary detection. Node deployments (Kantarci *et al*., 2011) consist of three classifications namely static deployment, self-adjustment deployment, movement assisted deployment. Among these deployments we have to choose an efficient node deployment algorithm for implementation. After the node deployment, localization technique has to be initiated with help of AUV (Autonomous Underwater Vehicle). Traditional localization techniques like SBL and LBL (Han *et al*., 2013) by using these combinations of two traditional techniques many localization protocols has been developed. In nowadays localization protocol is mainly classified in to Distributed localization protocol and centralized localization protocol.

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Transmission of information under the water can be done with the help of acoustic communication through the ocean (Kantarci *et al*., 2013) where as electromagnetic waves travel much shorter distances in underwater than they do in air. So they are not suitable for proper communication. GPS-based localization schemes are not suitable for UWSN because high-frequency GPS signals don't propagate well in water. UWSN is one of the enabling technologies for the development of ocean observation systems. Applications of UWSN like aquaculture and include instrument monitoring, climate recording, predict natural disturbances under sea level, underwater survey missions, pollution control and study of marine life. UWSN consist of sensors and vehicle for the monitoring purpose. To find the location of particular initiator node, distance has to be calculated between initiator node and anchor node. Distance will be calculated using time based approaches.

Localization techniques are of two types distributed localization techniques and centralized localization techniques. In distributed localization techniques, each node computes its own location and positions individually there is no central coordination. Using the collected localization information location estimation algorithm can be run individually in each node to find its location and positions.

In centralized localization technique (Han *et al*., 2013), there is a central coordinator among the nodes. The central coordinator collects all localization related information and runs the location estimation algorithm then sends back to all the underwater sensor nodes. In distributed localization techniques bandwidth utilization is very less (Han *et al*., 2013) where as in centralized localization technique bandwidth utilization is very high and also needs to be synchronized, resulting consuming higher energy. By using the distributed localization techniques we can reduce the computation complexity, minimize travel time and distance. Hence, due to energy consumption centralized localization becomes overhead in underwater whereas distributed localization techniques solve this issue.

The Estimation based technique (Bay *et al*., 2008), compute the current location based on the most recent information of the particular sensor node whereas the prediction based uses previous location information and current location information. The prediction based technique doesn't provide the accurate values of position and location of the sensor node due to ocean current.

When transmitting and receiving the beacon signals in underwater sea environment there maybe lot of obstacles in between anchor node and sensor node if signal falls on the obstacles or may be on the sea bed get diffracted or reflected and then to reach the sensor node. In this study we focus on the on the classification of the links and how it can be analyzed to produce location accuracy in UWSN.

MATERIALS AND METHODS

System scenario: When the sensor node comes in to the coverage area unaware sensor node s initiate a broadcast message to the anchor nodes α_i. So model consists of one or more transmitter and receiver pairs, s, α_i where s is unaware sensor node and α_i be the anchor nodes for exchanging a single communication packet. Let y_i be the propagation delay measurements from vector $Y = [y_1, y_2, ..., y_N]$ and corresponding measured time t_i:

$$y_i = y_{LOS} + n_i$$

where, $y_{LOS}$the propagation delay in the LOS link and n_i is zero mean value for LOS links. or nonzero mean for NON-LOS links i.e., for OLOS and SLOS. (Fig. 1) LOS (Line Of Sight) has only the propagation delay whereas SLOS (Sea Related LOS) and OLOS (Object Related LOS) contains absorption loss, reflection loss and propagation delay. Let d_{LOS} is the distance corresponding to y_{LOS}, i.e., $d_{LOS} = y_{LOS}$ c:

$$TL_{LOS}(d_{LOS}) = PL(d_{LOS}) + AL(d_{LOS}) + \in$$

where, TL_{LOS} is the Total Loss, PL Propagation Loss and AL Absorption Loss are the propagation absorption coefficients and $\in$ is the noise:

$$PL(d_{LOS}) = \gamma \log_{10}(d_{LOS})$$
$$PL(d_{LOS}) = \alpha \frac{d_{LOS}}{1000}$$

whre, α, γ are the absorption and propagation coefficient. Similarly for O_{LOS} links with distance, $d_{LOS} = d_{OLOS.1} + d_{OLOS.2}$. Where $d_{OLOS.1}$ and $d_{OLOS.2}$ are the distances from source to object and then object to receiver. So we conclude total loss for OLOS is as follows:

$$TL_{OLOS}(d_{OLOS}) = TL_{LOS}(d_{OLOS,1}) + TL_{LOS}(d_{OLOS,2}) + \text{Reflection Loss}$$

Classifying links: d_i^{PD} = c.y_i. Calculate $d_i^{RSS,LB}$ using received signal strength, propagation and absorption

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Table 1: Binary evaluation of position accuracy based on LOS and NLOS links

LOS	NLOS	Position accuracy
0	0	No estimation
0	1	Inaccurate/more AL and RL
1	0	Accurate/more propagation delay
1	1	Accurate

Table 2: Binary evaluation of position accuracy based on SLOS and OLOS links

SLOS	OLOS	Position Accuracy
0	0	Might be LOS/accurate
0	1	Inaccurate/more AL and RL
1	0	May be accurate
1	1	Accurate

Table 3: Binary evaluation of position accuracy based on LOS, SLOS and OLOS links

LOS	SLOS	OLOS	Position estimation
0	0	0	No Estimation
0	0	1	Inaccurate/more AL and RL
0	1	0	Accurate/inaccurate
0	1	1	Inaccurate
1	0	0	Accurate
1	0	1	Accurate/inaccurate
1	1	0	Accurate
1	1	1	Accurate/inaccurate

coefficients and $TL_{LOS}(d_{LOS})$. If $d_i^{RSS,LB} > d_i^{PD}$ then classify y_i as OLOS link Else. Exclude OLOS measurements from Y to form vector Y^{eY} and group two mixtures LOS and SLOS into one. Identifying LOS by estimating initial estimation ϕ^0 from the group.

Classification of los links: Links can be classified into three LOS, SLOS and OLOS respectively, SLOS and OLOS are considered to be NON-LOS links. Above Table 1. shows the position accuracy among the LOS and NLOS links. Further classification of NLOS link also need to be verify based on position accuracy among SLOS and OLOS as shown in Table 2. Binary evaluation for cumulative position accuracy among three link classifications LOS, SLOS and OLOS respectively as follows in Table 3.

Based on the communication type we need to prioritize the links from the binary evaluation analysis LOS and SLOS links having the higher probability of position accuracy.

Identifying los and non-los links

Identifying olos links: PD measurement $y_i \in Y$ is OLOS based on the following calculations; estimation of d_i^{PD}, estimation of $d_i^{RSS,LB}$ and finally setting the threshold by compare these two estimations. If RSS based range value is greater than PD based range estimation then link is said to be OLOS else it will be named either LOS or SLOS link and went for further classification.

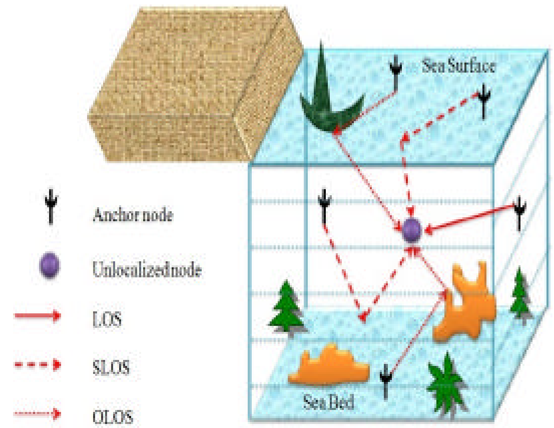

Fig. 1: Consider network modle

Identifying LOS and SNLOS links: After classifying the OLOS links excluding propagation delay measurements from Y and the remaining elements of Y are combined to form vector Y^{eY} it consist of two group of elements namely, LOS (C = 1) , SNLOS (C = 2) links. Parameter ω_c are to be estimated.

Optimizing the likelihood function: Let the random variable be the classifier of group ψ_l such that if ψ_l is associated with class C, $C \in \{1, 2\}$ then $\mu l = C$ and also let $\mu = [\mu_1, ..., \mu_l$ Since elements in Y^{eY} are assumed independent:

$$\Pr\left(\mu 1 = c - \left|1\psi_{1_p}\phi^p\right.\right) = \left(k_c{}^p p\left(\boxed{\Psi}_1 - \left|\omega_c\right.\right)\right)$$

Log-Likelihood function of μ given Y^{eY} conditional probability distribution and then we need to estimate the ϕ^p as follows:

$$L\left(\phi - 1\phi^p\right) = E\left[\ln(\Pr)\left(Y^{eY}, \mu\phi)\right)Y^{eY}, \phi^p\right]$$
$$= \sum(m=1)^2 \left[\sum_{(l=1)}{}^L \Pr(\mu_1 = c - 1\psi_1\right.$$

Initial estimation of ϕ^0: ϕ^0 Estimation is based on identifying a single group of elements from Y group whose elements belong to the LOS class with higher priority of probability, $\Pr(\mu_i = 1) \approx 1$. In order to classify two sets from a group Y_s^{eY}, c = 1, 2 we need to evaluate mean, variance and kurtosis of the elements from vector Y_c^{sY} denoted as $E[Y_c^{sY}]$, $Var[Y_c^{sY}]$, $K[Y_c^{sY}]$ respectively, for the estimation of ϕ^0 using the following distributions, show in Fig. 2:

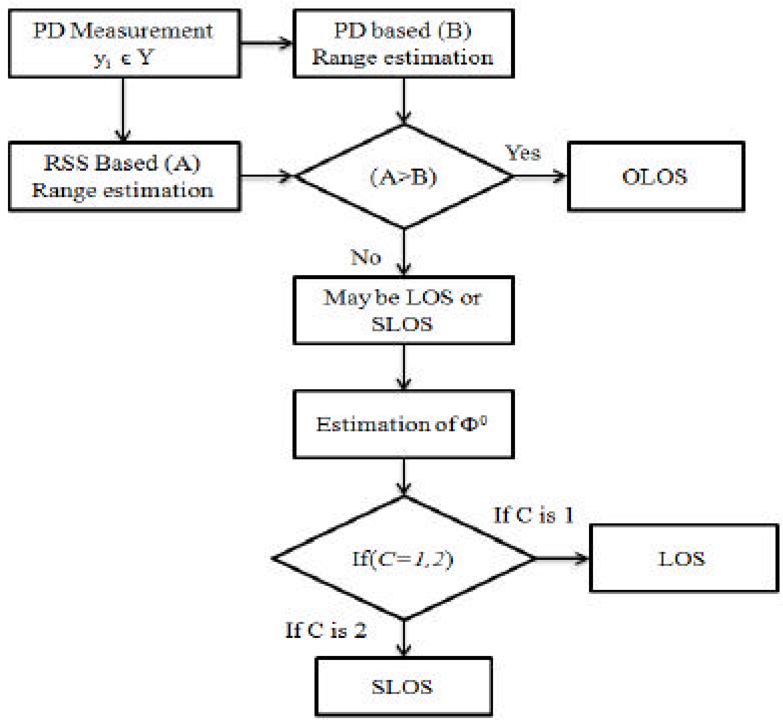

Fig. 2: Flowchart for classifying links

$$\frac{\left|Y_c^{sY}\right|}{\left|Y_c^{sY}\right|} = kc, E\left[Y_c^{sY}\right] = v_c$$

$$Var\left[Y_c^{sY}\right] = \frac{\sigma^2 c\Gamma\left(\frac{3}{\beta_c}\right)}{\Gamma\left(\frac{1}{\beta_c}\right)}, k\left[Y_c^{sY}\right] = \frac{\Gamma\left(\frac{5}{\beta_c}\right)\Gamma\left(\frac{1}{\beta_c}\right)}{\Gamma\left(\frac{3}{\beta_c}\right)^2} - 3$$

RESULTS AND DISCUSSION

Simulation is done in Matlab which demonstrate the performance evaluation of localization scheme. Results are in the terms of LOS, SLOS and OLOS links. Assumed simulation parameters are as follows ToA method for measuring based on Time of Arrival, simulate scenario (different nodes and obstacle length and locations), get different ten random ToA for each distribution parameters, simulation area length 1000 in meters.

Assumed fixed parameters are as follows Ts is 0.03825 duration of transmitted symbol measured in sec, carrier frequency 15×10^3 Hz, sampling frequency 20×10^3 Hz, number of ToA measurements is 200, maximum length of impulse response 0.1 sec, maximum value of beta is 6, á absorption loss 2 $dBkm^{-1}$, SL source level of 100 dB. RL reflection loss of objects 5 dB, mean of random factor in channel path loss 0 dB, variance of random factor in channel path loss 25 dB, minimum range 50 m, maximum range 1000 m, number of channel paths 2, number of obstacles 4, length of each obstacle 20 m. Probability will be vary by varying the number of nodes, priori probability will be high when number of nodes increases with respect to propagation coefficient γ. Figure 3 shows the effect of Propagation delay coefficients over priori probability on NONOLOS and OLOS it contains both LOS as well as SLOS.

Sources of errors: There are three major sources of errors for time-based location detection schemes in UWSNs (Webster *et al*., 2013) receiver system delay, underwater multipath fading and variable acoustic speed underwater. The receiver system delay is the transmission time duration from which the signal reaches the receiver antenna until the signal is completely decoded by the receiver. This time delay is determined by the receiver. The underwater multipath fading channel includes multipath propagation, speed of the receiver, interference with the surrounding objects and the transmission signal bandwidth. In underwater environment some other parameters which affect the communication which

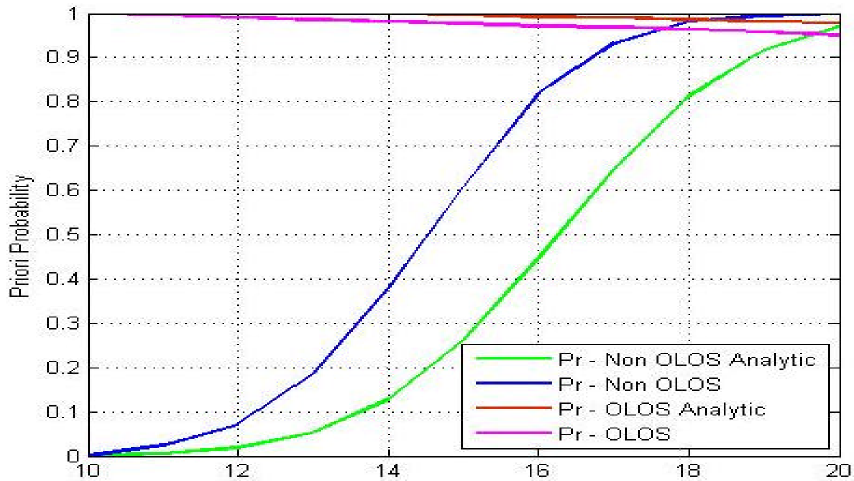

Fig. 3: Propagtion delay coeffiecients

includes temperature, salinity, underwater objects, pressure and clarity, motion behavior of receiver and transmission range.

CONCLUSION

In this study, we first investigate the basic fundamentals of UWSNs, then classification of links. For the improved accuracy, in position estimation identification the following link types like LOS, OLOS, SLOS are undertaken. Further, this Classification is based on propagation delay measurement, LOS and SLOS provide better position accuracy than OLOS. Binary evaluation of position accuracy based on LOS, SLOS and OLOS links are verified. Excluding the OLOS link, consider only the LOS and SLOS link values for position the estimation.

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