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A Unique Approach to 3D Localization in Wireless Sensor Network by Using Adaptive Stochastic Control Algorithm

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Abstract: In the modern era, wireless sensor network has turned into a critical innovation for various sorts of the clever algorithms, where nodes localization was complicated in research territory. A significant number of the advantages for wireless sensor networks are not profitable without a priory is known. Including Global Positioning System to every node is an exclusive plan and unsuitable for the indoor condition. Localization is a critical piece for wireless sensor networks innovation while current localization approaches, for the most part 2D plane has been concentrated, the rising 3D localization conveys WSNs nearer to improved exactness, and the 3D area innovation is more fitting for genuine applications. In any case, existing 3D localization has weaknesses, for example, high time complexity, low positioning exactness, and awesome energy utilization. Going for the current issues in present 3D localization methods, enhanced 3D localization technique based on adaptive stochastic control is proposed. Simulation results show that the average area precision of adaptive stochastic localization algorithm is vastly improved than established 3D DV-hop algorithm and centroid algorithm. Besides, the stability of the proposed method is superior to others. Anchor node system and propagation sample determination is used to simulate the spread of accuracy by 78.9% compared with 3D DV-HOP and 92.7% compared with the 3D centroid.

Keywords: 3D localization, GPS receiver, WSN, Adaptive Stochastic Control, Nodes

1 Introduction

The wireless sensor network speaks to gathered sensor nodes that is organized to play a specific errand. Localization has been important requirement in many applications in Wireless Sensor Networks (WSNs) [1]. For example, monitoring applications has been mainly dependent on nodes location and it seems that every company finds it difficult. Furthermore, by spreading particularly location-based routing techniques, the models dependent on which power efficiency can be improved [2]. However, each of its sensor node is attached to a Global Position System (GPS) device due to cost and some utilities that are ineffective in their limits. Then again, other non-GPS methods can be extended under both progressed and two classifications, hardware-based strategies and topology procedures [1, 3]. Signaling quality hardware methods, such as some information, can also help to sensor the edges. Seabed techniques are known to be very popular where 'seed' ends can help to determine a set of typical ends locations [3]. The most accurate prediction [2, 4, 5] showing that research can provide useful information on coordinating mobility in the growing and WSN distribution process.

An wide range of strategies has been proposed for settling this issue, yet a significant portion of them takes just 2D arrangements. Henceforth, localization issue of 3D proceeds with the testing issue in the scientific group. The most punctual attempt at 3D localization depends on trilateration. An unknown node has a similar plane and it does not have the correct separations. Four anchor points can be used to determine in the light of known directions, and getting an absolutely precise distance is unprocurable. WSN focuses mainly on the Euclidean separation using the Received Signal Strength Indicator

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(RSSI) or hop distance as a major parameter. As expected, the system topology that uses the trademark is widely grown there having an interest in traditions [6]. The CATL [7] parts are a whole strong network and a subset of each subnet which is optimized for anchor node design to increase the spread accuracy. Considering the node arrangement [8], free practices in the 3D area are dependable strict system pre requisites to significantly exceed the sensor systems themselves.

The centralized node localization estimation has been utilized to choose a region of every individual hubs since localization strategies have been computed, and localization nodes have been constrained. By grasping the proposed approaches, diminishing execution overhead of various nodes is observed. WSN nodes have restricted nodes communication and battery control, in order to overcome, the proposed work suggests the usage of Euclidean separation as unique parameter and a versatile or adaptive stochastic control strategies are used. Other basic clarifications behind utilizing adaptive stochastic control is that proposed distance estimation strategy that has been prepared for delivering sensibly precise distance measurement, and the suggested method can be gainfully associated on the fantastic model since it has been a closed form resolution for statistics examination.

The wireless sensor network nodes localization is classified into two types: range and range-free methods. The range-based methodology has been seen as more exact, and most of the techniques for limitation have a place with this group [6, 9–11] to utilize the distance between nodes. RSSI is the multiple precise understood framework that is appropriate for distance measurement. RSSI uses little resources without the extra necessity equipment. The anchor node computes the distance between the nodes in the transmission [12] region by using RSSI. The RSSI propagation speed is utilized with three different parameters like acoustic, infrared, and ultrasound signal.

Different types of nodes localization are used in a wireless sensor network, particularly fuzzy logic is used for anchor node localization. Purushothaman et al. proposed [13] anchor nodes divided the whole zone into areas with their neighborhood advertisements and helps to find the position. It moreover applies an improvement strategy to diminish confinement botch. The disadvantage of calculation has been required in arranging the correspondence nodes. Biljana et al. [14] introduced an hierarchical Multi-Dimensional Framework (MDF) given a 2D localization calculation which has three phases named as the formation of the clusters, intra-cluster localization and converging of neighborhood information.

The essential disadvantage of this strategy is that if there are many disjoint collective situations exist in the system, and from that point forward, it can wrongly compute the location. Additionally, Radu et al. [15, 16] upgrade the general centroid localization. By using 3D space algorithms, volume facilitates framework to increase the localization accuracy. Both the proposed ways utilizes anchor nodes, that anchor node localization accuracy has been contrarily relative to the quantity of anchor nodes that have suggested the utilization of the multi-dimensional framework for restriction of nodes in WSN [17]. They have proposed a passed-on localization method in light of a multi-dimensional structure where every hub makes an adjacent guide of the framework, and these maps are sewed together to shape an overall guide of the framework topology. Encouraging the nearby advancement is used to diminish restriction blunder. They run a dispersed and iterative calculation on every hub which realizes more vitality usage in the midst of the restriction stage.

The distance between all nodes localization stability based on the MDS is greatly affected. The wireless sensor systems are suitable for estimating the distance between all matched nodes. An indirect approach requires nodes to distribute distance between the pair which can provide specific distance data. This research proposes that a novel approach for distance evaluation between all pairs in the system fronts using adaptive control control. It has been found that the 3D distribution for the wireless sensor network is an issue for all over the system. Another propelled technique has been proposed in this work. This work reveals how different methods can increase 3D productivity. The simulation work is adaptive and non-existent control method uses the NS2 software to explain the effectiveness of the proposed strategy.

2 3D Localization Model

Localization intends to discover an area of nodes in a system. With the help of some foundation, a node can find its position in the system by removing data got from the framework; additionally, by making a node to send signals at delays. The structural edges can be calculated in the translation area nodes, if any reference centers about their geographic locations. GPS are the simplest technique for spreading the details that are not used to exchange the nodes status. However, it turns out to be too much if different nodes are in a mode. The amount of localized edges required by the power of anchor ends are discreet in their positions from beacon messages. Several methods have suggested that this relationship be reduced. If one node assesses its wrong area, at that point this mistake propagates to a general system and further nodes; therefore, false data of anchor nodes domain has propagated. To decide the position of nodes primarily depends upon the distance between anchor node and localized node.

In this work, a 3D localization algorithm which depends on adaptive stochastic control method is proposed. Since the work recommends the utilization of Euclidean distance as divergence parameter, adaptive stochastic control can be utilized as a part of our proposed method. Other huge explanations behind using adaptive stochastic control are that our proposed distance estimation strategy is fit for producing sensibly exact distance matrix and adaptive stochastic control can be productively connected on the solid model since it is a shut shape answer for data analysis. The communication and battery control of WSN have restricted the communication, these algorithms are helpful especially for location if nodes are in WSN.

3 Proposed Adaptive Stochastic Control for 3D Localization

To make 3D localization more efficient, our proposed method uses an adaptive stochastic control algorithm in order to implement a cluster based data transmission in the network. The routine evaluation consequences in series of situations verify that the data collection structure can make the packets with the same characteristics spatially convergent as much as possible and, therefore, this recovers the efficiency of data collection. The sensor is related to its bordering access point to get the sensor's information, and the entry point is connected with its closest sink to get the entry point's information. Every section point is set up with information collection, the sensors and sinks are single-antenna apparatus nodes. To enhance the localization process, the entrance points are used towards getting the sensors' information data and angle previously to transmit the signals. A key thought of the proposed method is to find out the mid-point with an anchor limit. Stochastic control method continuously finds out parametric point along all the sides of triangles. Ring control techniques are used to control the anchor node vector matrix.

Fig. 1 shows the workflow of data collection depending on the trust measure, in our proposed system, a practical result for data collection in the network is shown. An unknown node is the distance of anchor node to reach through following steps. The position of each anchor terminal is taken from the anchor IDs to the latitude and longitude of the GPS. All the related data can be recognized by each anchor nodes in the sense of its unit size.

The GPS sphere is integrated and each anchor node is synchronized with a Cartesian to integrate. Earth's vector is an anchor node (x,y,z), $a = m > 4$ and then each anchor terminals select another end of the parametric triangle where it can be $\{A_1,A_2,A_M\}$. Assuming that the anchor is available at the center of the maximum distance between the nodes is assumed. One anchor node is selected by three near anchor nodes to form 3D space.

3.1 Mathematical model for selecting the pre-localized node

The selection of pre-localized node depends on RSSI. The mathematical expression of RSSI is

$$RSSI = A_T - A_L + F_D \tag{1}$$

where $A_T, A_L, F =$ are anchor nodes.

The amount of RSS feels more than initial value at pre-defined node, and the replay will be stopped. ASCA is calculated to C_k at a sphere of distance

$$Ck = \begin{bmatrix} x_{1,k} & y_{1,k} & z_{1,k} \\ x_{2,k} & y_{2,k} & z_{2,k} \\ \cdots & \cdots & \cdots \\ x_{i,k} & y_{i,k} & z_{i,k} \end{bmatrix} \tag{2}$$

3.2 Estimation of Node Position

From the (x,y,z) localization coordinate, the most infrequent and minimum assessments are focused to improve the accuracy. By the way, the difference between the best and the structure in the light of each center is considered a prison block, which is prepared for after-effect

$$V = (x_{\max} - x_{\min})(y_{\max} - y_{\min})(z_{\max} - z_{\min}) \tag{3}$$

To find the spread centers, we activate the limitation and segment each monotonic scale and enable the range block from the Cartesian previous controlled center.

$$V_u = \frac{V}{N} \tag{4}$$

where $V_u =$ unit volume.

3.3 Classical Adaptive Stochastic Control Algorithms for Grouping Nodes

Data collection using the sensor, activates and announces new tests to each requests that are received in the network. The trust amount has been interested in preparation connotation summaries of a data log into some organized area, to exploit data group time. In these methods, an information gathering moves to pre-determined particular point for data collection in the system and each sensor node act separately for collectivity process in the network. It assesses the information gathering of two distinct groups, specifically the grouping between the sensor and access point, and the information between the entrance point and sink. We begin new scientific disputes for the average information proportion and inspect the effect of the information gathering of the collection on the overall average privacy price.

3.3.1 Algorithm

Grouping nodes Gn, Neighbor node NN
$Gn = group(NN(Gn))$.
For together Gn_i

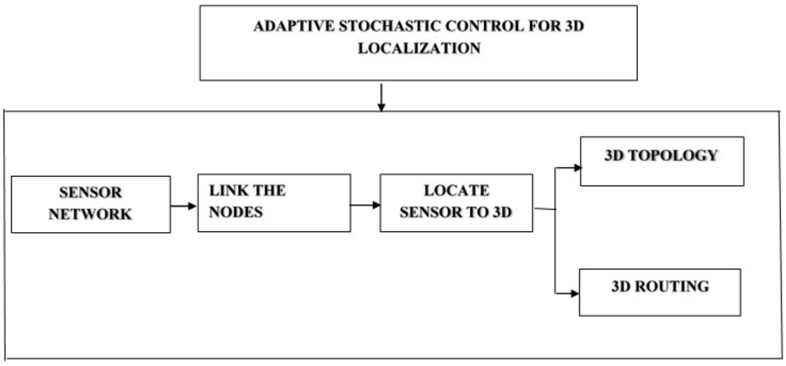

Fig. 1: Work flow diagram of adaptive stochastic algorithm in WSN

Increasing alteration $NN = \mu(\sum \sigma^2(nodes * Gn).)$
$Gn = set(n(NN))$/link bulk node)
Trust measure TM = neighbor allocation.
If $TM > NN$ then
$TM(i) = Gn/D(i) = 0 - Gn(i) = n$.
The node can be grouped successfully.
End
End
Stop.

The above algorithm shows trust measure-based grouping node for data collection, at that time all nodes are communicated to each other for data transmission. Using this adaptive stochastic technique quickly gives high security during data transmission in a wireless sensor network.

3.4 Adaptive Stochastic Control for Localization

The stochastic adaptive control algorithm with correlated information should be gathered for more efficient data collection. The planned system works on data localization with high-security manner using the trust measure. Actually, in the similar situation, our data collection structure should consume an improvement over the current data localization structure providing work for the upright in the network. Once the sensor nodes receive the inspiration communications, the device nodes of the particular section starts to send the collected packet in the network. The obstruction from the entrance point forces a general effect on the data collection between the entrance point and the sink. In this manner, the impedance from the entry motivations lessens the regular confidentiality rate. Another reflection is that the average protection rate enhances with expanding the thickness of sink because the separation between the specific access point and the accommodating sink creates shorter.

3.4.1 Algorithm

Input: Number of packets NP
Output: Data collection ASCA
Step 1: Classify set of separate nodes
obtainable altogether the routes
Step 2: For each node recognized
Group all nodes
Contribution = $\{p_1, p_2, \ldots, p_3\}$ where
The entire node can be grouped
End
Step 3: Produce topology after packet transmission
Step 4: Calculate no of packets
Step 5: Data will be collected

$$ASCA = \sum_{k=1}^{mo} (p1 - NP)^2$$

Step 6: Achieve all the output
where K represents the number of
units in hidden layer
Step 7: Update the neighbor information
Step 5: Add routes to best route set
Step 6: Stop

The above algorithm describes the data localization process in a network. It has to take the neighbor node for data collection. So overall data collection process secures and increases the overall throughput performance of the system.

The workflow diagram of Fig. 2 shows adaptive stochastic control method implemented in WSN. Received signal strength of the RSS node measurement is the main factor in determining the target when compared to the values of the target.

4 Results and Discussion

The proposed algorithm presents all the geometric ways to deal with the localization issue, by requiring a unique

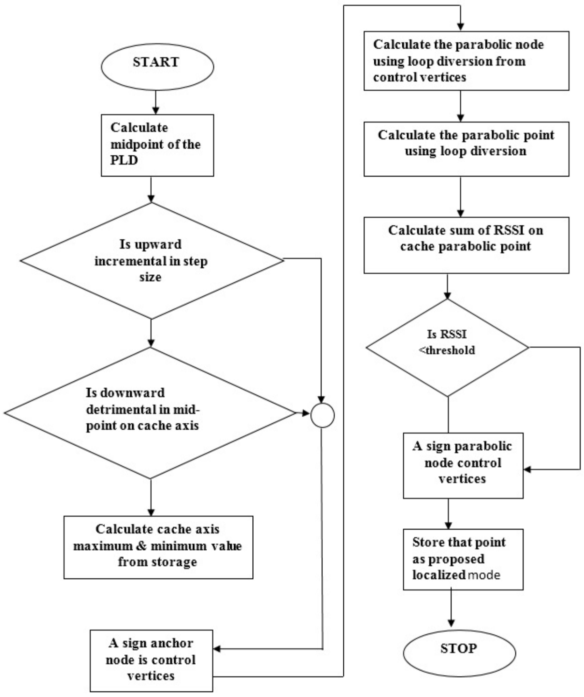

Fig. 2: Workflow flowchart in adaptive stochastic control algorithm

Table 1: Details of simulation metrics of proposed protocol

Parameter	Value
Imitation Platform	NS2
Reproduction Area	1000×1000 m
Amount of nodes	200
Broadcast Range	100 m

Table 2: Effect of radio range

No of nodes per layer	Radio range (M)	% success in proposed method	Total time (sec)
150	4	87.9	3.1120
150	5	86.9	3.0456
150	6	88.6	3.345
150	8	97.5	4.345

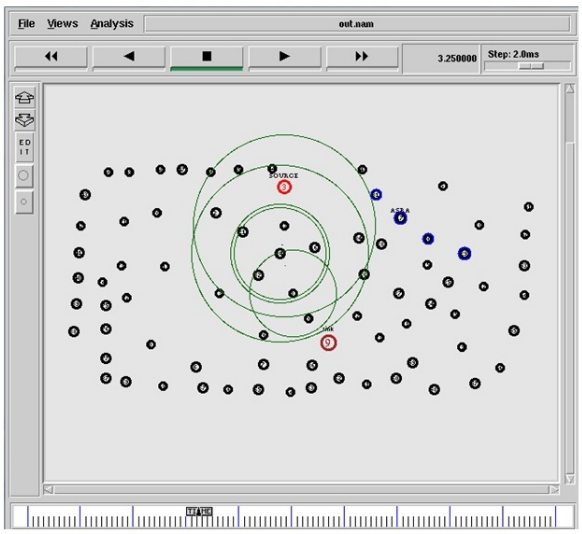

Fig. 3: Node localization process using ASCA

number of sensor nodes and location-aware beacons. The system tests are made by NS2, since it is chosen as it effortlessly handles the network simulation productively and all the worry of the work can be given to the real work instead of continuing programming details.

Table 1, shows the details of localization that are used to estimate the presentation of the proposed approach.

Fig. 3 shows the data collection using the data collection trace analysis in the network, and the trace analysis must use ASCA (Adaptive Stochastic Control Algorithm) for secure data collection, using this ASCA node all the information is collected securely.

The execution watches the varieties in radio range. The table gives the simulation output. The above simulation is completed taking the interlayer division 3m. As the proposed method uses both the range and range-based techniques, there isn't much execution change in it.

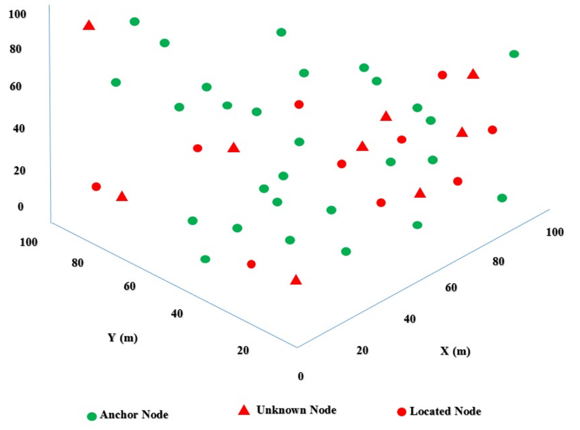

Fig. 4: The effect of the 3D-ASCA algorithm

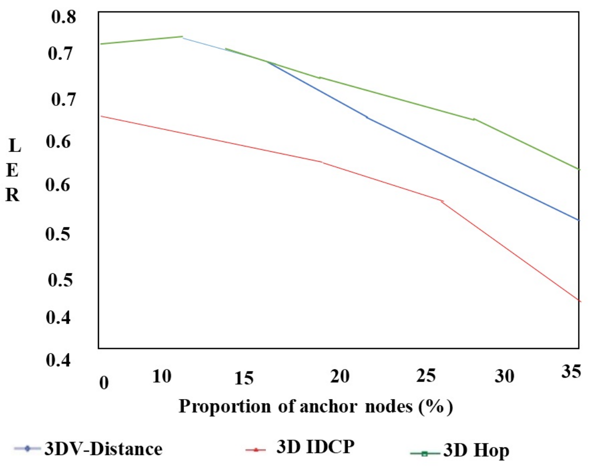

Fig. 5: Comparison of Localization Error Ratio (LER)

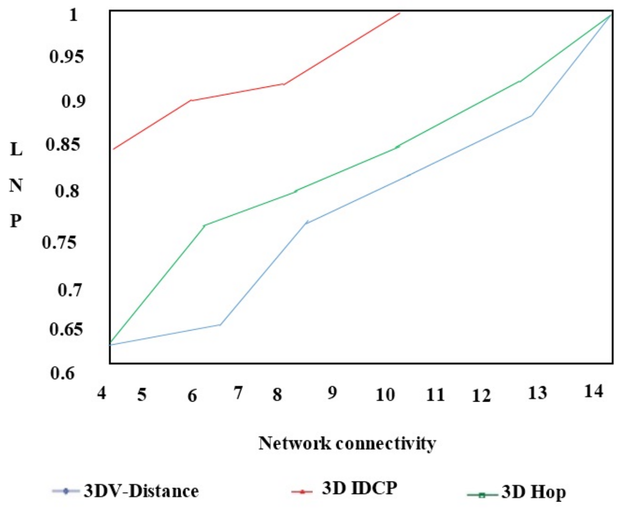

Fig. 6: Comparison of Localized Node Proportion (LNP)

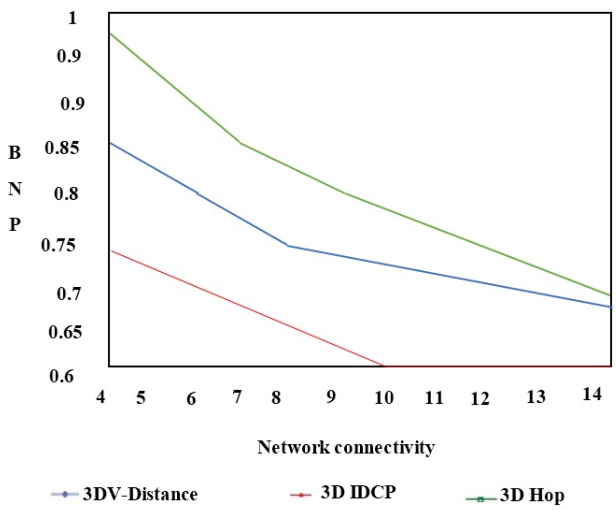

Fig. 7: Comparison in Bad Node Propagation

The effect of 3D-ASCA is shown in Fig. 4. In this figure, green circles represent the anchor node of 3D space, red circles represent unknown node

In Fig. 5 3D translator technique demonstrates three types of Localization Error Ratio (LER). Based on the average value, the proposed 3D-ASCA gives best result against 3DV-hop algorithmic translation error rate. There are 18% reduction in LER and 3DV-mass scale and 23% compared to a 3DV-hop algorithm. The Localized Node Proportion (LNP) is shown in Fig. 6.

Fig. 7 shows three types of 3D spread methods: PNB. The 3D-ASCA is less harmful than the nodes and has two other techniques. When our plan comes up to 10, the system has no wrong node which may be regulated. Our idea is more than the other two techniques.

It is observed from the Table 3 that our proposed algorithms have been better than a 3DV-centroid algorithm and 3DV-Hop algorithms.

The performance analysis of different 3D localization algorithms is discussed in Fig. 8. As compared with other algorithms the proposed algorithm gives the best results against all parameters. The classical adaptive design that has been presented above is unexpectedly advanced with different parameters, and all the variables in optical properties and classification have benefited effectively.

5 Conclusion

In this work, Adaptive Stochastic Control Algorithm(ASCA) has been proposed to enhance the 3D localization performance in wireless sensor networks.

Table 3: Localization errors of different range free methods with anchor nodes variations

Anchor Nodes (%)	Range	Centriod	3D-HOP	ASCA
	Minimum	5.711	5.512	4.802
4	Average	3.368	3.270	2.667
	Minimum	0.876	0.829	0.732
	Minimum	4.703	4.526	3.771
10	Average	2.806	2.616	2.213
	Minimum	0.740	0.706	0.553
	Minimum	2.866	2.771	2.182
20	Average	1.794	1.641	1.295
	Minimum	0.523	0.310	0.318
	Minimum	1.122	0.756	0.803
30	Average	0.821	0.702	0.607
	Minimum	0.022	0.11	0.0019
	Minimum	1.013	0.720	0.631
40	Average	0.605	0.455	0.365
	Minimum	0.017	0.014	0.0004
	Minimum	0.757	0.729	0.496
50	Average	0.330	0.324	0.243
	Minimum	0.013	0.010	0.0020

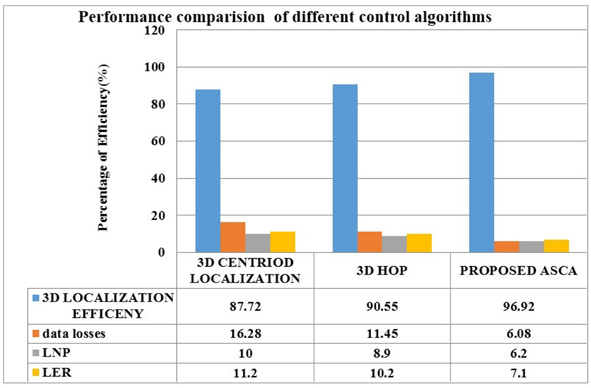

Fig. 8: Performance analysis of different algorithms

ASCA method, for the most part, adjusts the directions of localization nodes and the extension of nodes. The ASCA technique is simulated with NS2 to enhance the 3D localization process in a much better way. To further improve, the localization process is done based on uniform topology, communication range, number of beacon nodes and the localization accuracy. The conclusion can be made that the ASCA calculation can altogether enhance the localization accuracy of 3D wireless sensor systems, when compared with other conventional localization methods. Moreover, the ASCA algorithm positively affects the hazardous condition.

References

[1] H. Zou, X.X. Lu, H. Jiang and L.H. Xie, A Fast and Precise Indoor Localization Algorithm based on an Online Sequential Extreme Learning Machine, Sensors, 5, 1, 1804-1824, (2015).

[2] Q. Zhang, C.H. Foh, B.C. Seet and A.C.M. Fong, Location Estimation in Wireless Sensor Networks Using Spring-Relaxation Technique, Sensors, 10, 5, 5171-5192, (2010).

[3] M. Shon, M. Jo and H. Choo, An interactive cluster-based MDS localization scheme for multimedia information in wireless sensor networks, Compute. Common., 35, 15, 1921-1929, (2012).

[4] M. Seifieldin, A. Saeed, A.E. Kosba, A.E. Keyi, M. Youssef and M. Nuzzer, A Large-Scale Device-Free Passive Localization System for Wireless Environments, IEEE Trans. Mob. Comput., 12, 7, 1321-1334, (2013).

[5] S. Ravindra and S. Jagadeesha,Time of arrival based localization in wireless sensor networks: A linear approach., Signal & Image Processing: An International Journal(SIPIJ), 4, 4, 13-29, (2013).

[6] W. Meng, L.H. Xie and W.D. Xiao, Decentralized TDOA Sensor Pairing in Multihop Wireless Sensor Networks, IEEE Signal Process. Lett., 20, 2, 181-184, (2013).

[7] Y. Zhu, D. Huang and A Jiang, Network localization using an angle of arrival, In Proceedings of the IEEE International Conference on Electro/Information Technology, Ames, IA, USA, 205-210, (2008).

[8] J.A. Jiang, X.Y. Zheng, Y.F. Chen, C.H. Wang, P.T. Chen and C.L. Chuang, A Distributed RSS-Based Localization Using a Dynamic Circle Expanding Mechanism, IEEE Sens. Journal, 13, 10, 3754-3766, (2013).

[9] M.I. AlHajri, A. Goian, M. Darweesh, R. AlMemari, R.M. Shubair, L. Weruaga and A.R. Kulaib, Hybrid RSS-DOA technique for enhanced WSN localization in a correlated environment, International Conference on Information and Communication Technology Research(ICTRC), abudhabi, United Arabu Emirates, 238-241, (2015).

[10] János Simon,Comparison of different mobile WSN node localization techniques within the controlled microclimatic environment, IEEE 12th International Symposium on Intelligent Systems and Informatics (SISY), Subotica, Serbia, 79-82, (2014).

[11] D. Angeline Ranjithamani and A. Suruliandi, Performance evaluation of the energyefficient localization techniques in WSN, Computing Communication & Networking Technologies(ICCCNT), Third International Conference, Coimbatore, India, 17, (2012).

[12] Rui Rong Wang, Xiao-Qing Yu, Shu Wang Zheng and Yang Ye, Design of a TDOA location engine and development of a location system based on chirp spread spectrum, Springer plus, 5, 1, 217, (2016).

[13] P. Purusothaman and S. Sivakumar, Fuzzy RSSI Based Localization in Wireless Sensor Networks, International Journal of Engineering Research & Technology (IJERT), 2, 8, 1323-1328, (2013).

[14] Biljana Risteska Stojkoska and Danco Davcev, MDS-based Algorithm for Nodes Localization in 3D Surface Sensor Networks, The Seventh International Conference on Sensor Technologies and Applications, Barcelona, Spain, 44-50, (2013).

[15] Radu Stoleru and Tian He, Asymmetric Event-Driven Node Localization in Wireless Sensor Networks, IEEE transactions on parallel and distributed systems, 23, 4, 634-642, (2012).

[16] T. Nižetić Kosović and Jagušt, Enhanced Weighted Centroid Localization Algorithm for Indoor Environments, International Journal of Computer, Electrical, Automation, Control and Information Engineering 8, 7, 1219-1223, (2014).
[17] X. Ji and H. Zha, Sensor Positioning in wireless ad-hoc sensor networks using multidimensional scaling, in Proceedings of 23rd Annual Joint Conference of the IEEE Computer and Communications Societies (INFOCOM '04), 2652-2661, (2004).
[18] Shi Zhang, Baihai Zhang, Meng JooEr and Zixiao Guan, A novel node localization algorithm for anisotropic wireless sensor networks with holes based on MDS-MAP and EKF, IEEE Region 10 Conference (TENCON), Singapore, 3022-3025, (2016).
[19] Xiaoling Sun, Tao Chen, Weiqin Li and MianZheng, Performance Research of Improved MDS-MAP Algorithm in Wireless Sensor Networks Localization, International Conference on Computer Science and Electronics Engineering, Hangzhou, China, 587–590,(2012).
[20] Dan Jia, Weihua Li, Peng Want, Xinxi Feng; Hongyan Li and Zhiqiang Jiao, An advanced distributed MDS-MAP localization algorithm with improved merging strategy, IEEE International Conference on Information and Automation (ICIA), Ningba, China, 1980-1985, (2016).

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