IOSR Journal of Electronics and Communication Engineering (IOSR-JECE)
e-ISSN: 2278-2834,p- ISSN: 2278-8735.Volume 13, Issue 2, Ver. II (Mar. - Apr. 2018), PP 10-14
www.iosrjournals.org

Innovative3d Localization Technique Based On Antenna Radiation Pattern

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Abstract:*Localization without considering antenna radiation pattern gives a significant error which can be minimized .we propose a novel technique of localization based on antenna radiation pattern for finding 3D location of sensor node in a wireless sensor network by using radiation pattern of antenna with received signal strength indication. Proposed localization algorithm is developed by considering target node equipped with half wave dipole antenna which has omnidirectional radiation pattern. The results show that proposed algorithm estimates 3D location of sensor node in a sensor network with low average error (<0.495m).*

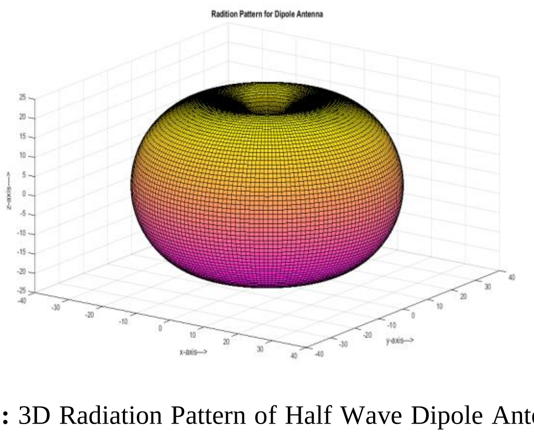
Keywords*-Localization, Dipole antenna, Received Signal Strength Indication (RSSI).*

Date of Submission: 22-03-2018 Date of acceptance:07-04-2018

I. Introduction

Development in wireless communications and electronics has enhanced micro sensors technology, smartness in controlling and monitoring sensors in a sensor network [1]. Wireless sensor networks are used for sensing physical factors like temperature, humidity and also for monitoring and detecting environmental factors, chemicals, smoke etc. There are many theoretical and practical works for designing and deployment of wireless sensor network. Authors of [2] proposed a deployment tool for wireless sensor network. After deployment phase, knowledge of sensor node location is crucial in many practical applications like forest fires location detection, marine monitoring, animal monitoring and so on. For outdoor localization GPS is used, but in indoor environment GPS does not work. Most of the localization works are based on 2D localization. In [3] and [4] they discussed RSSI based localization algorithms for 2D. In real-time applications, sensor nodes will be placed in three-dimensional space.

Most of the 2D and 3D localization techniques which depend on RSSI and path loss model always consider antenna radiation pattern as isotropic i.e. antenna radiates uniform power in all directions [11]. In practice isotropic antenna does not exist. Omnidirectional antenna is used as isotropic antenna because it radiates uniform power in all azimuth directions, but it has a deep null in the orthogonal elevation direction. It radiates less power in axial direction of the antenna as shown in Fig.1. Due to this, omnidirectional antenna or half wave dipole antenna radiation pattern gives less received power at nodes which are placed at the bottom of the antenna. In practical scenario because of the antenna radiation pattern effect localization error could increase. This motivated to propose new radiation pattern based 3D localization algorithm, which considers radiation effect to give less error in localization**.**



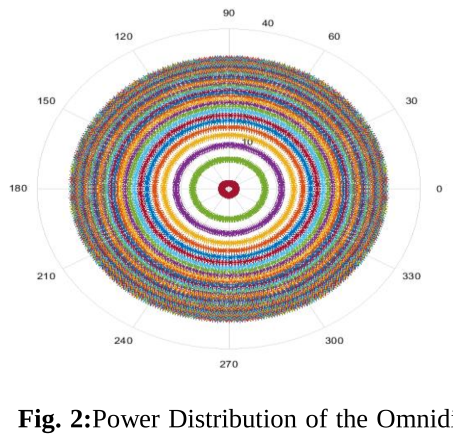


Fig. 1: 3D Radiation Pattern of Half Wave Dipole Antenna. **Fig. 2:**Power Distribution of the Omnidirectional Antenna in Horizontal Plane.

II. Proposed 3D localization algorithm

This section describes the proposed radiation pattern based 3D localization technique. We assumed that target node (sensor node to be estimated) is equipped with half wave dipole antenna, which has omnidirectional radiation pattern. In all directions, omnidirectional antenna radiation pattern is not same. It radiates less power in the axial direction of antenna. 3D radiation pattern of half wave dipole antenna is shown in Fig.1.

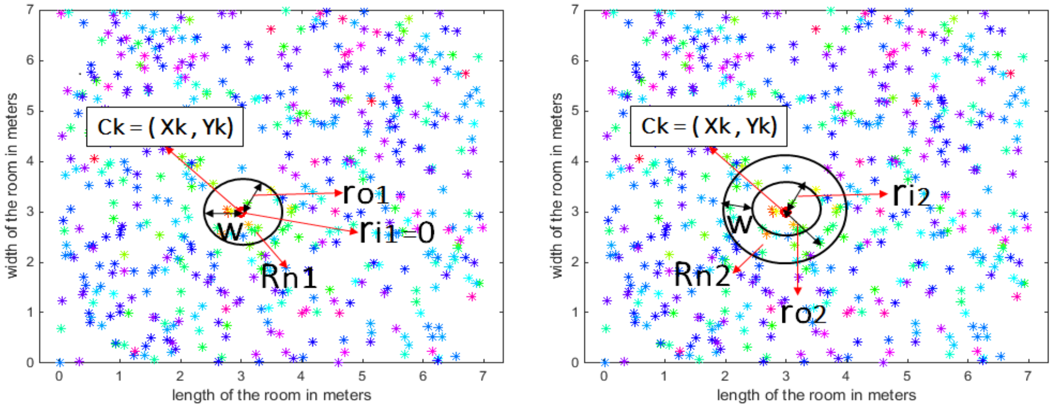


Fig. 3: The Defined Area is divided in Circular Rings**.**

(A) Estimating 2D Location of Target Node:

We considered that target node is placed above the XY-plane with antenna in Z-axis direction. Omnidirectional antenna radiates power concentrically in horizontal direction with circular patterns as shown in Fig.2. Received power from transmitting antenna at equidistant beacon locations is almost same on 2D plane (ground plane). The 2D location of the target node can be estimated by locating center of the circular patterns. To find out center of the circular patterns on 2D plane where beacon nodes are placed, the plane is divided in to circular patterns which are having arbitrary center point. These circular patterns form rings on 2D plane. Variance of received powers is computed over each ring. The mean of variances of received power where it goes to minimum, that center point of circles is regarded as 2D location of the target node.

To estimate target node 2D location (X_e,Y_e), we considered n beacon nodes in 2D plane. Location of beacon nodes are (x_i,y_i) where i = 1… n(a sensor node which is placed onmobile robot can be used as beacon node to get n beacon node locations. Received power of i^{th} beacon node isP_{r_i}. $R_{n_{kl}}$Represents l^{th} ring centered at an arbitrary point C_k = (x_k,y_k), where the radius of inner circle isr_{i_l}, outer circle is r_{o_l} and the width of each ring is w. Consider D_{ki} is the Euclidean distance between each points on 2D plane (x_i,y_i) and an arbitrary point C_k = (x_k,y_k) which is calculated from equation (1). $d_{1l}$is the minimum distance between l^{th} ring's inner circle circumference and the points lying inside the ring. $d_{2l}$is minimum distance between l^{th} ring's outer circle circumference and points lying outside the ring i.e. points which distance D_{ki}>r_{o_l}. $P_{ti}$is the set of points of beacon node locations. Algorithm starts at an arbitrary point C_k with r_{il}=0 and r_{ol}=w. In next step if d_{1l}<d_{2l} then r_{il}=d_{1l},r_{ol}=r_{il}+welse r_{ol}=d_{2l},r_{il}=r_{ol}-w . Fig.3 shows plot of two iterations. In iterative processd_{2l},d_{1l},r_{il},r_{ol} will be update until A_{kl}= {ϕ}.

D_{ki}=$\sqrt{(x_i - x_k)^2 + (y_i - y_k)^2}$………… (1)

Here the set of points located in the ring $R_{n_{kl}}$ are represented by A_{kl}= {P_{ti}|P_{ti} ∈ $R_{n_{kl}}$}.E_{kl}Represents the mean of received power at different beacon nodes in the ring $R_{n_{kl}}$ and calculated by equation (2).

E_{kl}=$\frac{\sum_{P_{ti} \in A_{kl}} P_{ri}}{n_{kl}}$…………………………... (2)

$n_{kl}$is the number of point of the set A_{kl}. Variance of received power values of each ring V_{kl}calculated using equation (3).

V_{kl}=$\frac{\sum_{P_{ti} \in A_{kl}} (P_{ri} - E_{kl})^2}{n_{kl}}$……………………… (3)

E_{V_k}=$\frac{\sum_l V_{kl}}{M_k}$……………………………….... (4)

Equation (4) is used to find the mean of the variances of the rings centered atC_k. Here M_k is the total number of rings forC_k. Finally the estimated position (X_e,Y_e) is determined using the following equation (5).

(X_e,Y_e)=C_k which minimizes E_{V_k}………… (5)

(B) Estimating height of the target node:

The gain of omnidirectional antenna in vertical direction is lower than horizontal direction (18) as shown in Fig.1. Thus, received power measured at the beacon nodes under the target node will be low. The average value of received power at beacon nodes from target node will decrease as target node height increases. This fact helped us to propose a new relative height estimation method for 3D localization.

To calculate average received power of beacon nodes under target node, a circle with radius r from estimated 2D location of the target node (X_e,Y_e) is considered. Set of Beacon positions M, which distance from (X_e,Y_e) is less than r is considered, i.e. M = {P_{ti} | D_{ki}< r}.$N_M$is the number of beacon node in the set M. Average received power of beacon nodes P_{avg} is calculated using equation (6).

$P_{avg} = \frac{\sum_{P_{ti} \in M} P_{ri}}{N_M}$ ………………………….. (6)

Specifically, the proposed algorithm estimates the relative height Z_{ej} of target nodesN_j. Here we assumed that all target nodes heights are uniformly distributed along Z-axis with different 2D locations. First we find the average received power of all target nodes (inside the circle with radius r under target nodes). The minimum P_{avg} value is denoted by$P_{avg_{min}}$, the corresponding height of$P_{avg_{min}}$, isH_{max} . To estimate relative height of other target nodes, received average powers of all target nodes are divided in to groups. K-means clustering algorithm is used for grouping the received average powers of different target nodes with different heights. K-means algorithm will give group numbers according to received average powers. All the target nodes are classified into M groups from G_1 to G_M depending on itsP_{avg}. The height of a target node in group G_h (where group number h=1, 2... M) is estimated by following equation (7).

$Z_{ej} = \frac{H_{max}}{M}$*h …………………………….. (7)

III.Algorithm implementation and simulation setup for 3D localization

The proposed algorithm is implemented using Matlab software. Radiation pattern of the half wave dipole antenna is generated with reference of [20], [21] using Matlab. To implement the algorithm we considered beacon nodes are randomly deployed on 2D plane. Target node is considered above 2D plane (which is placed in 3D location). Received power P_{ri} at randomly deployed beacon nodes (X_i, Y_i) depend on gain of the antenna at respective positions. Antenna Transmit gain $G_t(\theta, \phi)$and antenna receive gain $G_r(\theta, \phi)$ are function of azimuth angle $\boldsymbol{\phi}$ and elevation angle **θ**. Transmit and receive antenna gain of beacon nodes will be different for different azimuth angle $\boldsymbol{\phi}$ and elevation angle **θ** with respect to target node. Depending on these azimuth and elevation angles, antenna gains are mapped to different beacon node's location. To find received power at beacon node's location Revised Hata Okumara path loss model [19] is used (8).

$log D_i = \frac{1}{10\eta}[P_t - P_{ri} + G_t(\theta, \phi) + G_r(\theta, \phi) - X_a + 20log\lambda - 20\log(4\pi)]$……. (8)

Where D_i →distance between the target node to all beacon nodes (X_t, Y_t, Z_t) andi^{th} Beacon node (x_i, y_i)
$G_t(\theta, \phi)(dBi)$ → Transmit antenna gain
$G_r(\theta, \phi)(dBi)$ →Receiver antenna gain
$P_t(dBm)$ →Target node transmit power
$P_{ri}(dBm)$ → Measured received power at i^{th} beacon position
η → Measure of influence of obstacle like partitions and obstacles in indoor environment ranges from 4 to 5 and for free space it is equal to 2.
X_a → Normal random variable with standard deviation of α and varies from 3dB to 20dB.

Table: 1Path loss model parameter values used for simulation

Parameter	Value
P_t	-03(dBm)
X_a	3(dB)
Λ	0.1250(meters)
η	2.50

Simulation setup:

For simulation purpose we considered area of 7m*7m, number of beacon nodes are 1000 which are placed at random locations. All beacon nodes are placed on 2D plane with random azimuth angle. We considered all target nodes and beacon nodes are equipped with half wave dipole antenna. Along with this setup 10 target nodes are considered which are placed at different 3D locations. Considered number of groups are M=10 and considered maximum height is H_{max} =7m which is maximum height of the considered target nodes. To calculate average received power of beaconnodes under the target node, a circle with radius r=0.5m which centered at estimated 2D location is considered. TABLE: 1 shows path loss model parameters considered for simulation**.**

IV. Results analysis

Estimated location error with different heights is plotted in Fig.4. Actual, estimated locations are tabulated in Table II.

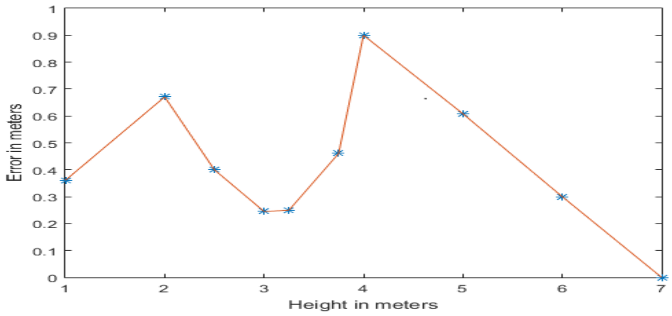


Fig. 4: Predicted location errorVsheight of the target nodes

Table II: Estimated and actual location of the sensor node at different heights

Actual locations(m)			Estimated locations(m)		
X_t	Y_t	Z_t	X_e	Y_e	Z_e
0	0	1	0.2	0	0.7
1	2	2	1	1.7	1.4
2	3	2.5	2	3	2.1
4	1	3	4.1	0.9	2.8
3	3	3.25	3	3	3.5
6	6	4	6	6	4.9
3.5	1.5	5	3.5	1.6	5.6
4	2	6	4	2	6.3
2	4	7	2	4	7
5	2	3.75	5.1	2	4.2

The error of the estimated 3D location of the target node to actual location of the target node is calculated by using equation (9).

$$E_{rr} = \sqrt{(X_t - X_e)^2 + (Y_t - Y_e)^2 + (Z_t - Z_e)^2}$$

Where(X_t,$Y_t Z_t$) →target node real location.
(X_e, Y_e, Z_e)→target node estimated location.
Estimated average error for 10 different locations with 10 different heights given in TABLE II is 0.4196m.

V. Conclusion

In this paper we proposed an antenna radiation pattern based 3D localization algorithm for estimating the 3D location of sensor node in a sensor network. The simulation results show that the proposed algorithm gives less average error (<0.495m) in estimating 3D location of target node compared to its actual location.

References

[1]. Seung-Ho Baeg, Jae-Han Park, JaehanKoh, Kyung-Wook Park, Moon-Hong Baeg. "RoboMaidHome: A Sensor Network-based Smart Home Environment for Service Robots", 16th IEEE International Conference on Robot &Human Interactive Communication 26-29, Augus 2007 / Jeju, Korea.

[2]. A. Srinivasan and J. Wu, "A Survey on Secure Localization in Wireless Sensor Networks, “Encyclopedia of Wireless and Mobile Communications, B.Furht (ed.), CRC Press, Taylor and Francis Group, 2008.

[3]. J.C.Navas and T.Imielinski. "Geographic Addressing and Routing”. In Proceedings of MOBICOM’97, Budapest, Hungary, September 26, 1997.

[4]. Y-B.Ko and N. H. Vaidya. "Location-Aided Routing (LAR) in Mobile Ad Hoc Networks”, In the Proceedings of MOBICOM'98, 1998.

[5]. N. Patwari, A. O. Hero, M. Perkins, N. S. Correal, and R. J. ODea, "Relative Location Estimation in Wireless Sensor Networks", IEEE Transactions on Signal Processing, VOL. 51, NO. 8, AUGUST 2003.

[6]. H. Gupta, S. R. Das, and Q. Gu," Connected Sensor Cover: Self-Organization of Sensor Networks for Efficient Query Execution”, In Proceeding of MobiHoc'03, Annapolis, Maryland, June 2003.

[7]. .Masashi Sugano, Tomonori Kawazoe, Yoshikazu Ohta, and Masayuki Murata. "Indoor Localization System using RSSI measurement of Wireless Sensor Network based on Zigbee standard", Wireless Sensor Networks 2006.

[8]. Gang Wang, Kehu Yang. "A New Approach to Sensor Node Localization using RSS Measurements in Wireless Sensor Networks", IEEE TRANSACTION ON WIRELESS COMMUNICATIONS, VOL. 10, NO. 5,MAY 2011.

[9]. SabastinGansemer, UweGroBmann, SyuzannaHakobyan."RSSI-based Euclidean Distance Algorithm for Indoor Positioning adapted for the use in dynamically changing WLAN environments and multi-level buildings ", International Conference on Indoor positioning and Indoor Navigation (IPIN) 2010.
[10]. N. Bulusu, J. Heidemann, and D. Estrin, "GPS-less low cost outdoor localization for very small devices",IEEE Personal communications Magazine, 7(5):28-34,October 2000.
[11]. Hong yang Chen, Pei Huang, Marcelo Martins, Hing Cheung, and Kaoru Sezaki, "Novel Centroid Localization Algorithm for Three-Dimensional Wireless Sensor Networks ", IEEE 978-1-4244-2108-4/2008.
[12]. Li Wang, Jing Zhang, Dun Cao, "A New 3-dimensional DV-Hop Localization Algorithm", Journal of Computational Information Systems 8: 6 (2012) 2463-2475, March 2012.
[13]. Guerrero E, Wang Hao, Alvarez J, Rivero L,"A Three-Dimensional Range-Free Localization Algorithm Based on Mobile Beacons for Wireless Sensor Networks", Vol. 20 No.1 June 2010.
[14]. Chang Liu, Hong Jiang and De-Long Zeng, "Unitary Matrix Pencil Algorithm for Range- Based 3D Localization of Wireless Sensor Network Nodes", Journal of Networks, Vol. 7, No. 9, September 2012.
[15]. Quan LIU, Ping REN, Zude ZHOU, "Three-dimensional Accurate Positioning Algorithm based on Wireless Sensor Networks". Journal of Computers, Vol. 6, No. 12, December 2011.
[16]. Baoli Zhang, Fengqi Yu Zusheng Zhang, "A High Energy Efficient Localization Algorithm for Wireless Sensor Networks Using Directional Antenna", 2009 11th IEEE International Conference on High Performance Computing and Communications.
[17]. Baoli Zhang, FengqiYu , "A Feasible Localization Algorithm for Wireless Sensor Networks Using Directional Antenna", 2010 12th IEEE International Conference on High Performance Computing and Communications.
[18]. Huey-Ru Chuang and Liang-Chen Kuo, "3-d fdtd design analysis of a 2.4-ghz polarization-diversityprinted dipole antenna with integrated balun and polarization-switching circuit for wlan and wirelesscommunication applications", IEEE Transaction on Microwave Theory and Techniques, 51:374-381,Febrary 2003.
[19]. Atreyi Bose and Chua HengFoh."A Practical Path Loss Model for Indoor Wi-FiPositioning Enhancement",ICICS 2012.
[20]. Balanis, C.A., "Antenna theory: a review", Proceedings of the IEEE,vol.80, no.1, pp.7, 23, Jan 1992
[21]. Scott, W.R., Jr., "A general program for plotting three- dimensional antenna patterns", Antennas and Propagation Society Newsletter, IEEE, vol.31, no.6, pp.6, 11, December 1989.

IOSR Journal of Electronics and Communication Engineering (IOSR-JECE) is UGC approved Journal with Sl. No. 5016, Journal no. 49082.

Vinod Kumar Netad"INNOVATIVE 3D LOCALIZATION TECHNIQUE BASED ON ANTENNA RADIATION PATTERN" IOSR Journal of Electronics and Communication Engineering (IOSR-JECE) 13.2 (2018): 10-14.