An Improve Performance Location RFID Algorithm Using 3-D Virtual LANDMARC Base On Passive Tag Technology

Heba A. Fayed, Iman Morsi, Ahmed Saad El Khatib

Abstract**—**Radio Frequency Identification (RFID) that enables tracking of people and objects indoor. 3-D LANDMARC has many problems but the 3-D Virtual LANDMARC can overcome the draw backs of 3-D LANDMARC like additional cost , improve the Localization accuracy , the problem of Radio Signal , the effect of reference Tags and without additional real Tags and Readers. Numerical Simulation Result show that the proposal algorithm is very simple and it gives higher location accuracy showed that enhances the precision of indoor localization the new k-nearest algorithm can provide better performance than the old one used in 3-D LANDMARC.

Keywords**—**K-nearest algorithm, LANDMARC, RFID, Virtual LANDMARC.

I. Introduction

THE RFID is a method for remotely storing and retrieving data that used to localized and tracking object or people in door environments .the Systems that map the longitude and attitude of an object are geo-location systems and generally use the Global Positioning System (GPS) for location mapping. GPS could be used as the location determination portion of RTLS system but GPS signals do not penetrate buildings well and thus GPS will in general not work well inside buildings and in dense areas [1]. Thus, there is a need for RTLS systems that work individually in those environments that are especially indoor environments. In order to locate objects accurately in indoor environments different technologies have been proposed for indoor localization including infrared (IR), ultrasound, and radio frequency (RF) systems [2]. The technique selection depends on the type and scale of the environment and the line of sight (LOS) is required or not. IR and ultrasound sensors require LOS and are short range devices so the systems using RF become popular because RF systems do not require LOS and can communicate in long ranges depending on the power of the signal. The most popular of these are received signal strength indication (RSSI), time of arrival (TOA), time difference of arrival (TDOA) or angle of arrival (AOA) [3]. The main idea of all these localization methods is that, in order to localize nodes, distance of the nodes to reference points, distance between nodes or angle according to reference points need to be calculated or estimated first. However, the methods except RSSI need complicated hardware or antenna which drastically increases the system cost [4]. This leads us to use RSSI based localization methods in our work. All three technologies can be used for indoor localization and we choose to use RFID technology which is the most popular RTLS system for indoor use due to its advantages of being practical, cost effective, small in size, and easy to deploy [5], [6], [7]. RFID devices compose of transmitters (or transceivers) called tag and receivers called reader which are cost effective, small size, and low power devices. Compared with an outdoor propagation environment, indoor environments are more complex in terms of RF signal propagation. Radio signals are subject to reflections, diffractions, in multipath or shadowing effect and scattering in complex environments

The rest of this paper is organized as follows. This proposal gives a brief overview of some related technologies in Section 2. In Section III we revisit RSSI-based Ranging Model and the 3-D LANDMARC approach, 3-D virtual LANDMARC detailed in Section IV. In Section V, we show simulation results between 3-D LANDMARC and 3-D virtual LANDMARC. Finally, we conclude this new algorithm in Section VI.

Heba A. Fayed, Iman Morsi are with the Arab Academy for Science, Technology &Maritime Transport (AASTMT) Alexandria, Egypt.

Ahmed Saad El Khatib is with the Communication Engineer, Military Technical College (e-mail: el_kateeb67ahmed@yahoo.com).

II. Related Technologies

Recently, significant researches have been conducted to devise accurate ways of determining indoor location [8-11]. These researches try to improve the accuracy of location, such as Spot ON [12], LANDMARC [13], Virtual Reference Elimination (VIRE) [12] and etc. Spot ON uses an aggregation algorithm for three dimensional location sensing based on radio signal strength analysis [12]. In the Spot ON approach, Spot On tags use received radio signal strength information as a sensor measurement for estimating inter-tag distance. However, a complete system has not been made available yet. The LANDARC system introduces the concept of having reference tags with known and fixed locations to adapt the environmental dynamics to help location calibration [13]. The proposed approach doesn't need a large number of expensive RFID readers but lots of cheaper RFID tags. Moreover, we can dynamically update the reference information for lookup based on the detected range from the reference tags in real-time to improve accuracy and reliability. VIRE is a RFID-based location system that aims to provide improvements over the LANDMARC approach [12]. It introduces the concept of virtual reference tags and proposes an algorithm to reduce positioning errors. The main idea of the proposed VIRE approach is to gain more accurate positions of tracking objects by filtering out those unlikely positions without adding extra reference tags.

III RSSI Based Ranging Model

RSS this method estimate the distance to calculate the signal path loss due to propagation. Theoretical and empirical models are used to translate the measured signal strength. Researchers have derived a significant relation between RSS and distance both for outdoor and indoor measurements [2]

A. Outdoor Area Measurements

Through Friis' formula the relation between the signal strength and distance is deduced for the outdoor area measurements [15]. Accordingly RSS is expressed as follows:

$$P_r = P_t - P_L\,(d) + G_r + G_t \tag{1}$$

where P_r is the received signal power (dB), P_t is the transmitted signal power (dB), P_L (d) is the path loss (dB), G_r is the receiving antenna gain and G_t is the transmitting antenna gain . P_L(d) is expressed as follows for free-space :

$P_L(d) = 10 \log(4\pi d/λ)2$ (2)

Where λ is wavelength d is used for the distance between the receiver and the transmitter.

B. Indoor Area Measurements

The actual attenuation rate varies, however, depending on the environment where the RFID system is deployed

$$P_{RX,\ reader} = P_{TX,\ reader}\ \eta\ G_{tag}^2\ G_{reader}^2 \left(\frac{\lambda}{4\pi d}\right)^{2n} \tag{3}$$

This shows that the signal strength is inversely proportional to d^{2n}, where n is referred to as the path loss exponent. The typical value of n is between 1.6 and 1.8 for LOS indoor environments, and between 2 and 6 for outdoor propagation environments [16]. η is the backscatter transmission efficiency of the passive tag. As a result, when the path loss exponent is known or can be estimated for a specific environment, range d can be estimated from RSS measurements [17]. The ratio between the backscattered signal power a reader receives from a passive RFID tag and the power of the reader transmits is illustrated in Fig. 1 where different values of path loss exponent n are considered. The following parameters are used: f =915MHz, η=1/3, G_{tag}=1 (or 0 dB), and G_{reader}=4 (or 6 dB). In practice, tags are expected to have low directivity, whereas a reader antenna gain of about 6 dB is commonly used because FCC regulations require proportional reduction of the transmit power when the transmit antenna gain exceeds 6 dB.

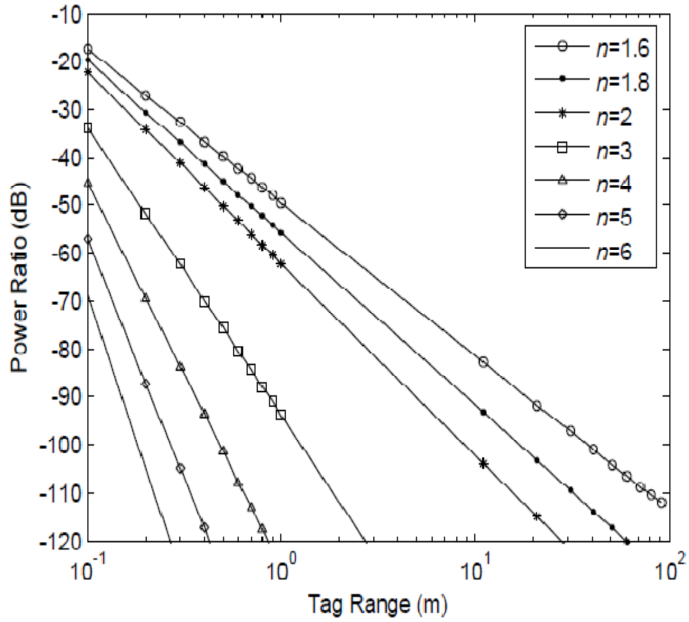

Fig. 1 Ratio between the received power and the transmitted power of a passive RFID reader for different path loss exponents (f=915 MHz, η=1/3, Gtag=0 dB, and Greader=6 dB)

IV. LANDMARC Locating Algorithm

Suppose that LANDMARC here is arranged as follows: n number of readers ,m number of reference tags and u tracking tags we define the signal strength vector of a tracking tag and reference tag as S_i= (S_1 , S_2 ,…….,S_n) and θ_i =(θ_1, θ_2……,θ_n) where S_i denotes the signal strength of the tracking tag perceived on reader i , and θ_i denotes the signal strength of the reference tag perceived on reader i , where in i ∈ (1,n) Euclidian distance in signal strength between a tracking Tag and a reference tag is defined by:

$$E_i = \sqrt{\sum_{i=1}^{n}(\theta_i - S_i)^2} \tag{4}$$

In (1) (i = 1 , 2 , ……. , m) , there will be shorter distance between a tracking tag and a reference tag as it is a smaller E_I while m is the number of reference tags and the upper count limit of neighboring reference tags as well. The nearest reference tags near a tracking tag are used to assisting locating the tracking one. When k nearest reference tags' coordinates are used to locate one tracking tag, it is called as nearest neighboring algorithm. The unknown tracking tag's coordinate (x, y,z) can be obtained by:

$$(x\ ,y\ ,z) = \sum_{i=1}^{k} wi(x_i, y_i, z_i) \tag{5}$$

where (x_i,y_i,z_i) is the coordinates of l-th reference tag, while w_i is the weighting factor to the l-th neighboring reference tag. The weight w_i is given by:

$$w_i = \frac{1/E_i^2}{\sum_{i=1}^{k} 1/E_i^2} \tag{6}$$

A. 3-D Virtual Reference Tags

The array Trilinear Interpolation has more than two dimensions, the value sought will be at a point within the interior of the corresponding prototype[13]. In the descriptions below, the functions for interpolation are assumed to be sufficiently close to linear suppose we have a nearly or exactly linear function

$$v = f(x, y, z) \qquad (7)$$

and we are given eight points, A, B, C, D, E, F, G, and H defining a right rectangular

Prism as shown below in Fig. 2

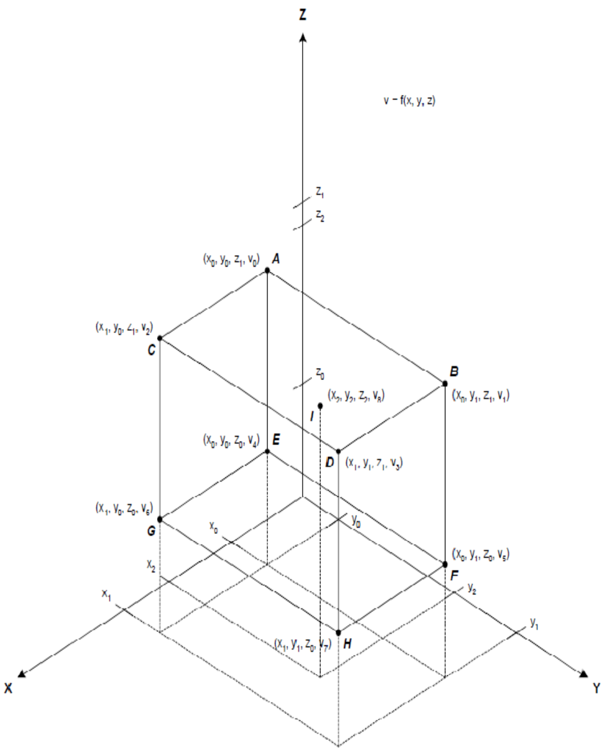

Fig. 2 Trilinear interpolation. The right rectangular prism ABCDEFGH is partitioned into eight volumes by the three Orthogonal planes passing through point I

The prism ABCDEFGH is partitioned into eight volumes by the planes $x = x_2$, $y = y_2$, and $z = z_2$ To interpolate the value (v_8) of f at point I (given at x_2, y_2, and z_2) we first find the normalized volumes of the partitions of the prism ABCDEFGH. The eight volumes are normalized by dividing them each by the volume of prism ABCDEFGH. The eight normalized volumes N_a, N_b, N_c, N_d N_e, N_f, N_g, and N_h, Then each diagonally opposite from its naming prism vertex, are given by

$$N_a=\frac{(x_1-x_2)(y_1-y_2)(z_2-z_0)}{(x_1-x_0)(y_1-y_0)(z_1-z_0)} \qquad (8)$$

$$N_b=\frac{(x_1-x_2)(y_2-y_0)(z_2-z_0)}{(x_1-x_0)(y_1-y_0)(z_1-z_0)} \qquad (9)$$

$$N_c=\frac{(x_2-x_0)(y_1-y_2)(z_2-z_0)}{(x_1-x_0)(y_1-y_0)(z_1-z_0)} \qquad (10)$$

$$N_d=\frac{(x_2-x_0)(y_2-y_0)(z_2-z_0)}{(x_1-x_0)(y_1-y_0)(z_1-z_0)} \qquad (11)$$

$$N_e=\frac{(x_1-x_2)(y_1-y_2)(z_1-z_2)}{(x_1-x_0)(y_1-y_0)(z_1-z_0)} \qquad (12)$$

$$N_f=\frac{(x_1-x_2)(y_2-y_0)(z_1-z_2)}{(x_1-x_0)(y_1-y_0)(z_1-z_0)} \qquad (13)$$

$$N_g=\frac{(x_2-x_0)(y_1-y_2)(z_1-z_2)}{(x_1-x_0)(y_1-y_0)(z_1-z_0)} \qquad (14)$$

$$N_h=\frac{(x_2-x_0)(y_2-y_0)(z_1-z_2)}{(x_1-x_0)(y_1-y_0)(z_1-z_0)} \qquad (15)$$

Then Z_8 is computed by the equation

$$V_8=Z_0N_a+Z_1N_b+Z_2N_c+Z_3N_d+Z_4N_e+Z_5N_f+Z_6N_g+Z_7N_h \qquad (16)$$

It is The easiest way to improve positioning seems to be increasing the number of reference tags a system contains and the closer they are located, the more accurate the localization should become. The number of RFID tags in the LANDMARC system as well as in every other RFID system however is limited due to bandwidth in the frequency band and used bandwidth per tag

RSSI values usually change only slightly between reference tags [7]. Hence, and the Virtual Reference Tags approach assumes that these changes are more or less liner and can be computed which leads to the possibility of implementing additional virtual reference tags into the system by using mat lab. Their RSSI values are then estimated by linear approximation between the RSSI values of the real reference tags. As using these virtual reference tags led to a much higher number of tags to be considered with the VIRE approach the virtual reference tag elimination was also introduced: Each reader holds a map of all virtual reference tags and marks those to be considered as 1, while all other ones are marked 0. Now a binary AND operation of all maps produces a new map consisting of only a few number of virtual reference tags to be considered. In this approach, the following advantages. First, additional readers and tags are not required. Thus the hardware cost is the same as the LANDMARC approach. Second, the estimated position of a tracking object is more accurate and simple to calculate.

V. SIMULATION RESULTS BETWEEN 3-D LANDMARC AND 3-D VIRTUAL LANDMARC

This algorithm uses the parameters reported in the previous research work [23] The assumption of LANDMARC algorithm is three readers (R), two tracking tags (TT) and eleven reference tags (RT). The Fig. 3 explains the placement of readers, reference tags and tracking tags, in3Dplane. As algorithm estimates best when reference tags are densely placed, hence placement of reference tags leads to 11 the readers are in continuous mode of operation. Readers reported RSS value for tracking tags and reference tags. Tracking Tag RSS vector is shown in Table I and Table II respectively

Euclidian distance vector (E) based on RSS vectors of TT and RT is shown in Table III, and computed by using (4). The vector E implies, the nearer the RT to TT the smaller is its Euclidian distance E .Weights corresponding between TT and RT are computed by using Euclidian vector E. The relevant weights implies, the nearer the RT to TT.

W_i implies that the reference tag with the smallest E value has the largest weight

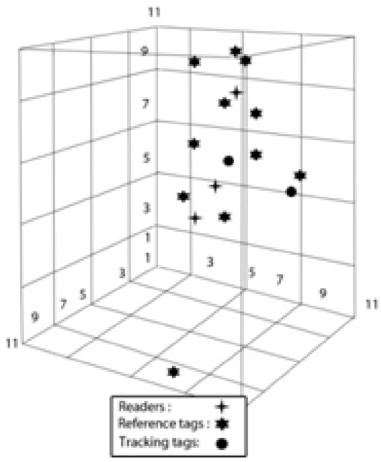

Fig. 3 Illustrate the placement of readers, reference tags and tracking tags, in 3D plane

TABLE I
RSS TRACKING TAG VECTOR (SI)

	R_1	R_2	R_3
TT_1	0.7646	0.7686	0.3648
TT_2	0.5413	0.6259	0.6314

TABLE II
RSS REFERENCE TAG VECTOR (ΘI)

	R_1	R_2	R_3
RT_1	0.8726	0.4165	0.8813
RT_2	0.8631	0.0178	0.0199
RT_3	0.8813	0.5097	0.0461
RT_4	0.8777	0.8862	0.0121
RT_5	0.5211	0.8468	0.0201
RT_6	0.5121	0.8506	0.8312
RT_7	0.3990	0.5010	0.8719
RT_8	0.0119	0.0194	0.8879
RT_9	0.4810	0.8401	0.8923
RT_{10}	0.4005	0.8511	0.7938
RT_{11}	0.0091	0.2619	0.8899

TABLE III
EUCLIDIAN DISTANCE VECTOR (E)

	TT_1	TT_2
RT_1	0.6345	0.4648
RT_2	0.8324	0.9205
RT_3	0.4271	0.6868
RT_4	0.3885	0.7513
RT_5	0.4292	0.6503
RT_6	0.5367	0.3022
RT_7	0.6801	0.3061
RT_8	1.1840	0.8449
RT_9	0.6031	0.3429
RT_{10}	0.5687	0.3113
RT_{11}	1.0505	0.6947

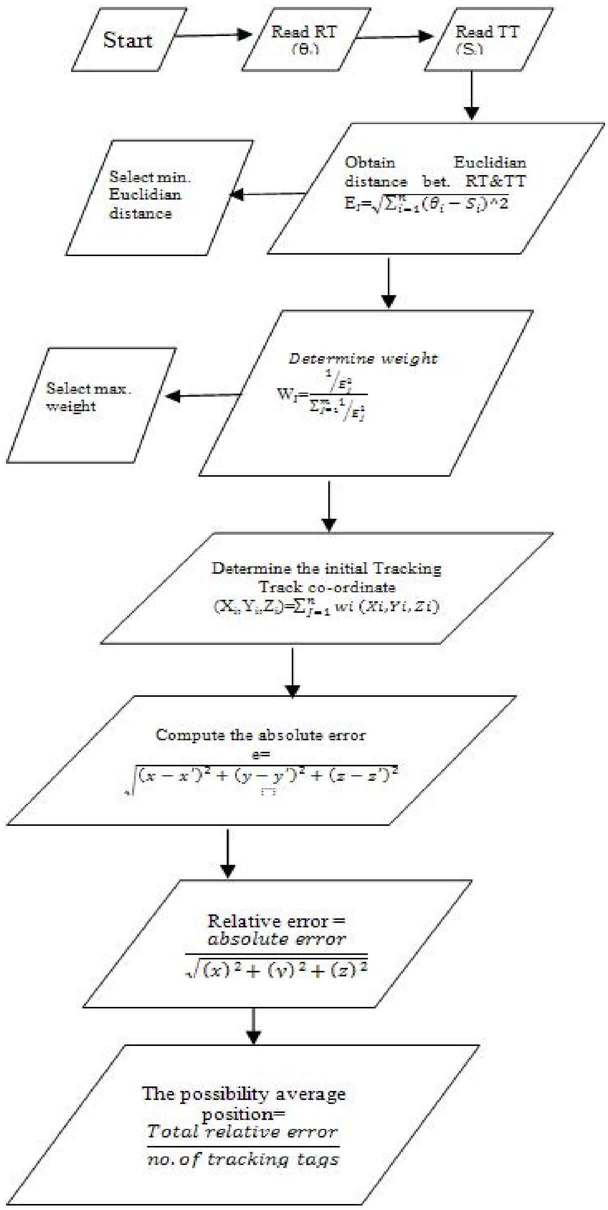

Fig. 4 Proposed adaptive k-nearest neighbor algorithm (The workflow of the LANDMARC)

Determining the k-nearest algorithm to decrease the error of position of tracking Tag

We know that the smallest Euclidean distance is got from the contrast of the vector S and the vector θ, then use weight value to obtain the signal strength plays crucial role in the whole algorithm. If the received signal strength value is of large errors, it will lead to accuracy decline of the whole positioning. However, the interference of the external environment is inevitable. Therefore , the improved k-nearest neighbors algorithm need to add the feedback correction , and the feedback correction will avoid the problem of declining of position accuracy caused by the receiving signal strength is not accurate . The whole process of the improved algorithm is shown as in Fig. 4

The Numerical simulation results show that using virtual landmark RIFD in a 3D environment has improved the absolute error1 and error2 by 30.26% and 12% for Tracking tag 1 and Tracking tag 2 for Tracking tag 1 and Tracking tag 2 respectively. Using linear interpolation step = 0.2, the best value here for selected number of reference tags is k ϵ [100] and [300] respectively. The number of realistic reference tags is 11 and the best absolute error1 and error2 is achieved at k=4 and 3 for Tracking tag 1 and Tracking tag 2 respectively. Fig. 5 and Fig. 7 show that absolute error against k-nearest neighbor algorithm TT1 and TT2 for respectively of 3-D LANDMARC. Fig. 6 and Fig. 8 show that absolute error against k-nearest neighbor algorithm TT1 and TT2 for respectively of 3-D virtual LANDMARC system.

Tracking tag 1	Actual Co-Ordinate1	3-DLandMarc 1	3-D virtual LANDMARC 1
X	6	6.3254	6.5357
Y	7	6.3356	6.9634
Z	6	5.4388	5.6784
Absolute error	30.26%	0.9285	0.6259

Tracking tag 2	Actual Co-Ordinate2	3-DLANDMARC 2	3-D virtual LANDMARC 2
X	9	8.6460	8.9969
Y	8	8.0222	7.2318
Z	5	5.4048	4.6704
Absolute error	12%	0.5382	0.4180

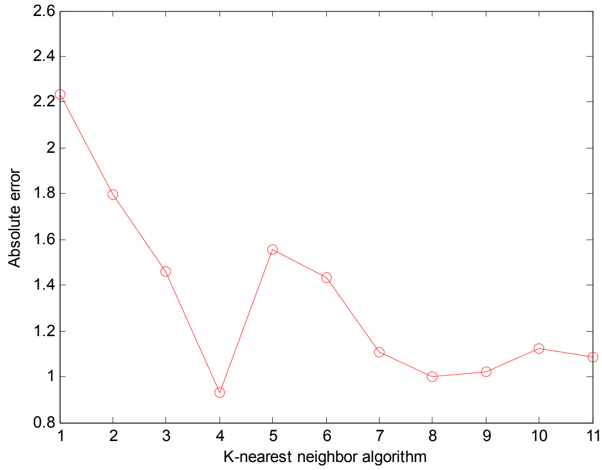

Fig. 5 3-D LANDMARC (TT1)

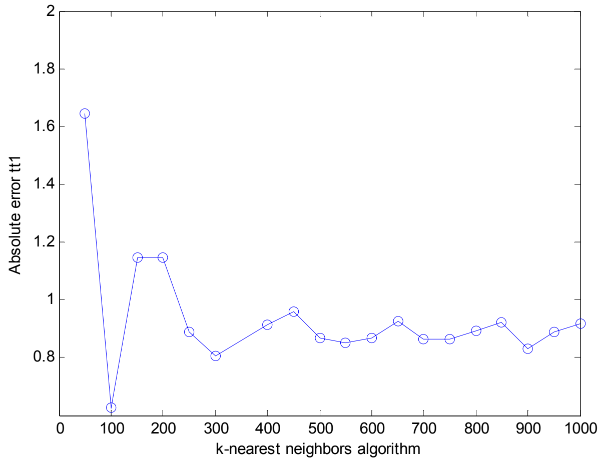

Fig. 6 3-D Virtual LANDMARC (TT1)

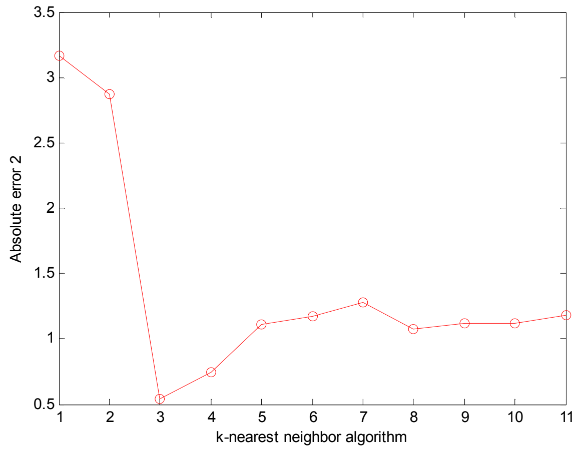

Fig. 7 3-D LANDMARC (TT2)

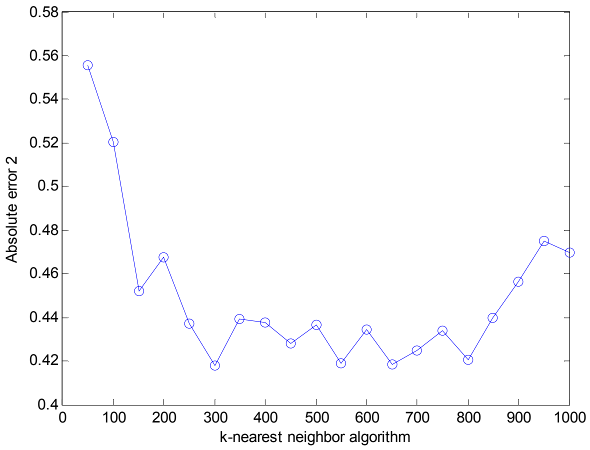

Fig. 8 3-D virtual LANDMARC (TT2)

VI. Conclusion

In this proposal , we investigate the implementation of the virtual landmark RFID in 3D environment according to the specific environment position the k-nearest neighbor algorithm of 3-D LANDMARC and 3-D virtual LANDMARC system have been Discussed and simulated. In order to increase the accuracy of location tracking tag.

It can be noticed that by implementing virtual reference tags, more tags have been introduced to our model and thus the possibility to obtain average absolute error occurred by 21%. Our future work will focus on the implementation of proposed systems in more real RFID applications.

References

[1] Dixit, V. V. A Particle Filter Based Framework For Indoor Wireless Localization Using Custom IEEE 802.15.4 Nodes, Arlington: M.Sc. Thesis, the University of Texas, 2008.

[2] E. Aydın, and R. Öktem. An RFID Based Indoor Tracking Method for Navigating Visually Impaired People, Turk J Elec Eng & Comp Sci, Vol. 18, No. 2, pp. 1-12, 2010.

[3] Lim, J. Tracking A Variable Number Of Targets Based On RSS Measurements In Wireless Sensor Networks, New York : PhD Thesis, Stony Brook University, 2007.

[4] Yeap, T. H. Analysis and Design of Neural Network- Based WLAN Indoor Location System, Ottawa : M. Sc. Thesis, University of Ottawa, 2007.

[5] X. Huang, R. Janaswamy, and A. Ganz. Scout: Outdoor localization using active RFID technology, 3rd Int. Conf. on Broadband Com., Networks and Systems, pp. 1-10, 2006.

[6] Sanpechuda, T. K. A Review of RFID Localization: Applications and Techniques,5th International Conference on Electrical Engineering/Electronics, Computer, Telecommunications and Information Technology, Vol. 2, pp. 769-2008.

[7] M. Bouet, and A. L. dos Santos. RFID Tags: Positioning Principles and Localization Techniques, 2nd International Home Networking Conference, pp. 1-5, 2008.

[8] Bagci F, Kluge F, Ungerer T, Bagherzadeh N. Optimisations for LocSens - an indoor location tracking system using wireless sensors [J]. Intern1ational Journal of Sensor Networks, Volume 6, Numbers 3-4, November 2009, pp.157-166.

[9] Priyantha N B, Chakraborty A, Balakrishnan H. The Cricket location-support system[C]. In Proceedings of the 6th annual international conference on Mobile computing and networking, 2000, pp.32-43.

[10] Yiming Ji, Saad Biaz, Santosh Pandey, Prathima Agrawal. ARIADNE: a dynamic indoor signal map construction and localization system[C]. In proceedings of the 4th international conference on Mobile systems, applications and services, 2006:151-164.

[11] Madigan D, Einahrawy E, Martin R P, Ju W H, Krishnan P, Krishnakumar A S. Bayesian indoor positioning systems. In Proceedings of the 24th IEEE International Conference on Computer Communications Societies, Vol. 2, 2005, pp.1217-1227.

[12] J. Hightower, R. Want, and G. Borriello. SpotON: An indoor 3D location sensing technology based on RF signal strength. UW CSE tech report 2000-02-02, University of Washington, Seattle, WA, Feb. 2000.

[13] Yiyang Z, Yunhao L, Ni L M. VIRE: Active RFID-based Localization Using Virtual Reference Elimination[C].The 2007 International Conference on Parallel Processing (ICPC 2007), 2007, pp.56-56.

[14] Kreysig, Erwin, Advanced Engineering Mathematics, Third Edition, John Wiley and Sons, Inc., 1972.

[15] K. Pahlavan, X. Li and J. Makela, “Indoor geolocation science and technology,” IEEE Communication Magazine, Vol. 40, pp. 112-118, February 2002.

[16] T. Rappaport, “Wireless Communications, Principle & Practice,” IEEE Press, Prentice Hall, pp. 3, 1996.

[17] Abdelmoula Bekkali, Horacio Sanson and Mitsuji Matsumoto, “RFID Indoor Positioning Based on Probabilistic RFID Map and Kalman Filtering,” Third IEEE International Conference on Wireless and Mobile Computing, Networking and Communications, White Plains, NY, October 2007.

[18] M Ayoub Khan, Videep Kumar Antiwal Location Estimation Technique using Extended 3-D LANDMARC Algorithm for Passive RFID Tag.