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RESEARCH ARTICLE - ENGINEERING

Improve the Positioning Accuracy for Indoor Applications Based on Hyperbolic Method with Optimum Measurement

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Abstract

The localization for indoor environments is faced by problems related to high error rates. To address this problem, a hyperbolic method is chosen which is a suitable for such environments. Also, such methods give a significant error when depending on RSS values, which suffer from unstable reading. To overcome this phenomenon, a proposed method is presented in this research to choose a suitable value of RSS. The idea is to install 4TXs in the chosen case study building and select the best two reading of 2TXs lying on the same side of the square case study building among four values of RSS measured from the 4TXs. The results show that, a significant reduction of error is achieved using the proposed method as the range of achieved error is between (0.1091, 0.0061) to (1.7162, 1.6593). While, the such range are from (0.0114, 0.0472) to (1.2685, 2.3207) by using 2TXs. Finally, a validation of achieved error is applied for the results of proposed method applied by real measurements. The results of such validation show that a close measurement to the simulation result is achieved.

Publisher : Middle Technical University

Keywords: Hyperbolic; RSS; WI; Wi-Fi.

1. Introduction

The indoor localization has become one of the important techniques in our lives, especially with smart phone applications and the Internet of things (IoT) [1, 2]. As indoor localization techniques have made our lives easier and safer, such as Wi-Fi, ZigBee and Bluetooth techniques [3], where people's location can be found in internal environments. Unlike Global Positioning System (GPS) technology, which lacks this feature, it is only used to locate locations in outdoor environments [4]. An indoor positioning system (IPS) is designed to provide information about a person's position within a building e. In general, an IPS has three requirements to be met for large-scale use: (i) the system must provide accurate position estimates, (ii) the system must be easily scalable, and (iii) the cost of implementation must be reduced [5]. Indoor localization suffers from many challenges such as noise, interference, reflections, barriers, and huge multipath [6, 7]. There are many techniques that are used to calculate the distance between transmitter (TX) and receiver (RX) and these techniques may be single or hybrid. An example of single, Time of Arrival (ToA), Angle of Arrival (AoA), Received Signal Strength (RSS) , Time Difference of Arrival (TDoA) and Frequency Difference of Arrival (FDOA), for hybrid such as, RSS/AoA, RSS/ToA, TDoA/ToA [8-10]. To estimate the position of the target, there are many techniques such as, trilateration, triangulation and Multilateration and hyperbolic [11, 12]. The hyperbolic is a technique used to determine the coordinates of the position based on the estimated distance between the TX and the RX, as well as on the RSS signal inside the site, as it is a set of points in a plan with distances to two fixed points to estimate the coordinates of the target. Hyperbolic position determination is also called " Multilateration." a common technique used for positioning when an absolute time reference is not present [13]. In the communication system, when we lose Line of Site (LoS) or strong direct signal, it leads to a huge multipath, these problems may be most affecting Wireless Local Area Network (WLAN) or environments where Wi-Fi technology is used [14, 15]. For simplicity and a reasonable price, we used 2.4 GHz with a bandwidth of 1 MHz in this study, this frequency is the most common in the Wi-Fi technologies in communications system [16].

In this research, the position will be estimated using the hyperbolic technique based on RSS. Also, improve the positioning based on such technique will attempt using the better two transmitters among more than 2TXs in the specific area. the experiment will be applied in the selecting building using Wireless InSite (WI) package to simulate such building, and all these steps will work through Wi-Fi technology and at a frequency of 2.4 GHz.

Nomenclature & Symbols			
IoT	Internet of things	TDoA	Time Difference of Arrival
GPS	Global Positioning System	FDOA	Frequency Difference of Arrival
IPS	Indoor Positioning System	LoS	Line of Site
TX	Transmitter	WLAN	Wireless Local Area Network
RX	Receiver	WI	Wireless InSite
ToA	Time of Arrival	ML	Maximum Likelihood
AoA	Angle of Arrival	GA	Genetic Algorithm
RSS	Received Signal Strength	PC	Personal Computer

2. Related work

Many researchers have tried in previous researches to work on the hyperbolic technique such as, [13] worked on estimating the location using Wi-Fi technology based on hyperbolic. Where they used an algorithm that combines signal techniques, sampling techniques and hyperbolic location estimation to estimate the location of mobile users. Also, this algorithm minimize complexity by reducing the number of fingerprint measurements while providing reliable accuracy of the site. In the same field, the authors of [17] are worked on analysing hyperbolic positioning algorithms using RSS measurements in WSN. In addition, the researchers of [18] uses standardized pseudolites (GPS ground-based), which are typically small transceivers designed to build a local, ground-based alternative to the GPS, were employed to overcome the weakness point of indoor location. The development of a multi-channel pseudolite and neighbouring antennae in an antenna array for hyperbolic positioning. According to the geometric relationship between the pseudo-antennas and the receiver, the testing result demonstrates that the positioning precision varies from centimetre to meter level. Moreover, the author in [19] proposed hyperbolic location fingerprinting, which records fingerprints as signal strength ratios between pairs of base stations instead of absolute signal-strength values. On signal-strength traces that were gathered over a ten-hour period using five different IEEE 802.11 network cards, the enhanced approaches were put to the test. The analysis reveals that the signal-strength disparity is resolved by the suggested remedy avoiding the need for additional manual calibration and delivers performance on par with currently available manual solutions. In addition, [20] the researchers in this paper worked on a hybrid approach combining the genetic algorithm (GA) and maximum likelihood (ML) is developed to estimate the position and velocity of the moving source using hyperbolic approaches based on TDOA and FDOA. The position and velocity localization data are first subjected to ML. In addition, GA is used to extract the non-linear equations set of the ML solution that is globally the best at resolving the localization parameters. The outcomes showed that the suggested approach did indeed accomplish the theoretical lower bound for close to far-field with the same and different velocity and various baseline of sensors in low to high Gaussian noise level. Additionally, in [21] a brand-new location estimation technique for Wi-Fi-based indoor positioning devices has been unveiled. To determine the location of mobile phone users, the proposed approach combines signal sampling methods and hyperbolic location estimation. The system provides accurate location information while using fewer fingerprint measurements to reduce costs. Furthermore, the current network infrastructure does not need any more hardware improvements. According to experimental findings, the suggested algorithm performs more accurately than conventional signal strength-based techniques using a simple-to-create signal strength database. Moreover, [22] proposed a method by which object position can be calculated analytically using TDoA analysis of the signals sent from the object transmitter to the base station receivers. This method has the potential to enhance the accuracy of coordinate determination when the TDoA measurement differs across base stations and demystifies the body coordinates in space. Satellite positioning systems and autonomous vehicle applications are being investigated. The gathered data demonstrated that the suggested method has higher accuracy in finding coordinates than the linear method using deterministic equations and is less sensitive to TDoA variations at base stations.

3. Methodology

The hyperbolic Technique based on RSS. In this research, a hyperbolic technique based on RSS is deployed in order to estimate the position of the target with a chosen building.

To estimate the distance between Tx and RX, the RSS method is used in this research to calculate such distance [23]. The RSS value represents the power received by the receiver with the effects of noise and interference Signal to Noise Ratio (SNR) as in Equation (1) [24, 25]

$$RSS = P_r + I_{total} + N_{total} \tag{1}$$

Where $\boldsymbol{P_r}$ is the received power, $\boldsymbol{I_{total}}$ is the total interferences and $\boldsymbol{N_{total}}$ is the total noise within the examined area.

Estimated distances are used as an important parameter used with the hyperbolic technique.
A hyperbolic technique is a set of points in a plane with constant differences from two fixed locations represented by a point $\boldsymbol{N_1}$&$\boldsymbol{N_2}$ in the plan. The references node is represented by the hyperbola's focus [26]. To calculate the position, the destination must be on a hyperbolic curve between the two points, as shown in Fig. 1.

The hyperbolic equation is represented by (2) [27].

$$\frac{x^2}{a^2} - \frac{y^2}{b^2} = 1 \tag{2}$$

Where, $\boldsymbol{x}$ & $\boldsymbol{y}$ represent the coordinates of position, *a* and *b* are values determined from the following equations (3, 4):

$$a^2 = \left(\frac{\Delta d}{2}\right)^2 \tag{3}$$

$$b^2 = (\frac{D}{2})^2 - a^2 \quad (4)$$

Where D the distance between two points of hyperbola, Δd is the difference in distance between the two fixed points and the target, Δd represented in equation (5):

$$\Delta d = d_2 - d_1 \quad (5)$$

Where d_2, d_1 is the distances between the reference points and the target.

To estimate the distances between the reference points (N_1&N_2) and to the Target (T) can be calculated by equation (6) [28].

$$d_i = 10^{-(\frac{RSSI - P_T + P_{l0} - X_\sigma}{10 * \gamma})} \quad (6)$$

Where P_T is the transmitted power, P_{LO} is the path loss, X_σ is the range of 2-14 of dependent on the surroundings of the case study according to the previous references, and γ is the path loss exponent and is in a range of 2-6.

The hyperbolic technique it is use to estimate the position of a target node in the RSS process by using the equation (7) to determine the coordinate x, to determine the coordinate y based o equation (2) as shown in equation (8)

$$x = \frac{x_2^2 + d_1^2 - d_2^2}{2 \, . \, x_2} \quad (7)$$

$$y = \pm x * \frac{b}{a} \quad (8)$$

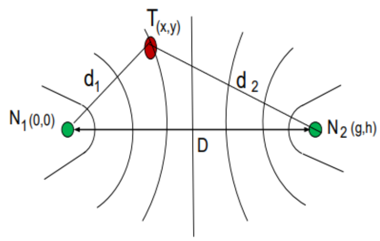

Fig. 1. The hyperbolic Technique

4. Case study building

The goal of this work is to estimate the location coordinates by using hyperbolic technique based on RSS. Our experiment was conducted in a selected case study region, which is shown in Fig. 2.

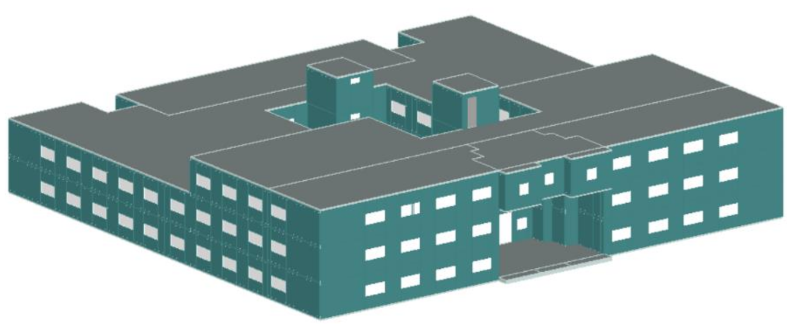

Fig. 2**.** The case study building

This building consists of three floors, our experience in this research will be limited only to the first floor. This building was simulated using WI package, whereby hyperbolic technique used to estimate the position coordinates based on RSS.

To apply the hyperbolic method, 2 TXs are installed at the beginning of the building TX1&TX2.The distance between them is represent the D access of Fig. 1. Another model of hyperbolic, which is represented by TX3 & TX4 in a same building are choosing at the end place of such building. Same manner is applied as in the beginning model. All TXs are represented by red points, while RXs are represented by black points in Fig. 3.

To improve the accuracy and reduce the error coordinates, a proposed method is presented in this paper. The idea is to install 4TXs (one in each corner of case study floor). Each 2TXs on same line are represent D access of Fig. 1. In order to apply the hyperbolic method on any side the square case study, the proposed method included a selection of 2 better measurements of RSS from 2TXs, which are installed in the same side, in order to apply hyperbolic method to estimate the position of RX, as shown in Fig. 4.

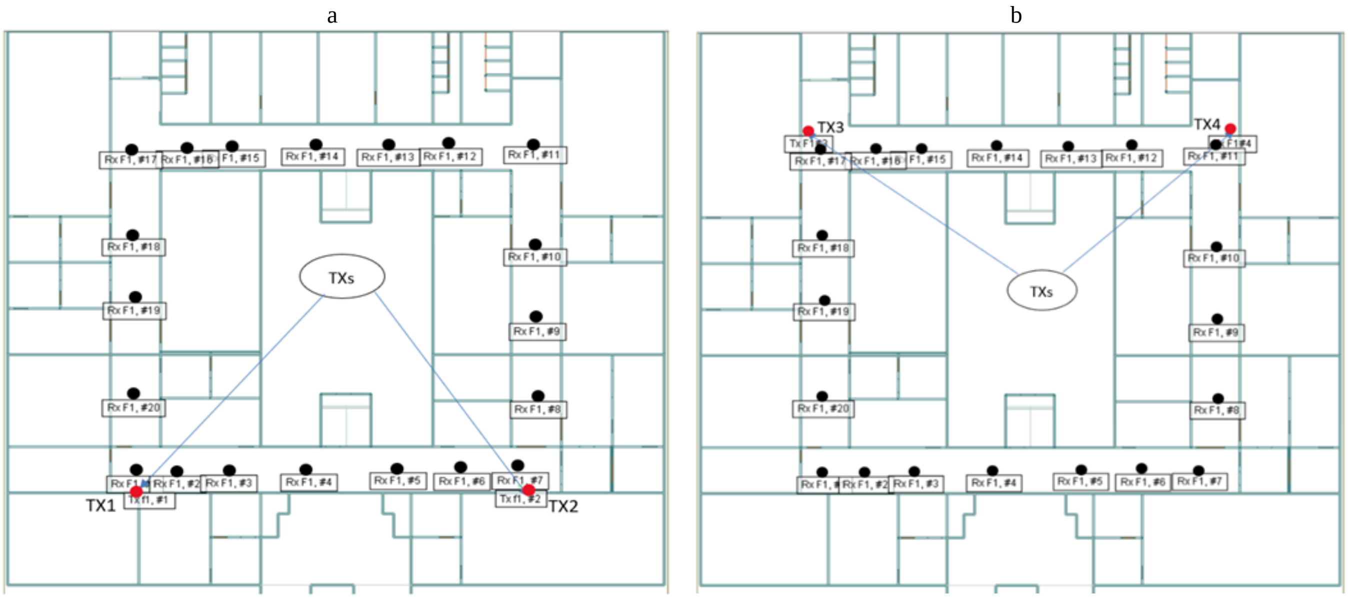

Fig. 3. Distribution of 2TXS in two different ways.(a) in the beginning building, (b) in the ending building

Fig. 4. The deployment of 4TXs & 20RXs

5. Results and Discussions

In this research, our experiment will be applied in two parts: the simulation and real measurement parts.

5.1. The simulation part

The simulation part is divided into two sub-sections:

The first one, deployed 2TXs in the beginning and at the end of case study building. The real measurement will apply the same procedure of simulation part and compare between them.

Firstly, 2TXs are installed in the beginning represented by TX1&TX2. The results of this step are listed in Table 1A (Appendix A) under TX1&TX2 columns. Such results are used to estimate the position by calculate each $\boldsymbol{d_2}$& $\boldsymbol{d_1}$ using equation (6). Such calculations are used to estimate the position using equations (7&8). The results of all calculations are listed in Table 1A under the columns $\boldsymbol{d_2}, \boldsymbol{d_1}$, *x,* and *y*. Also, the real position is listed in same table in order to calculate the error coordinates listed in Table 1A. It is worth to mentioned that the values of RSSI are taken from TX1&TX2 of Table 1A, while other parameters of equation (6) are listed in Table 1.

Table 1. The parameters are used in distance equation

parameters	values
d_o	1 (meter)
P_T	12 (mW)
P_{LO}	35(dB)
X_σ	12 (dB)
γ	4

In addition, same procedure is applied for TX3&TX4 which are installed at the end of the case study building. All results are listed in Table 2A (appendix A). Note that all calculations of the simulation part are extracted using the WI package. As mentioned in section (4) case study, the method of improve positioning which is included a selection of two better results among 4 reading of RSS are chosen as better RSS values which are a colored in red as in Table 2. Then the procedure of estimation for all RXs are applied in the same previously manner, the steps of procedure are shown in Fig. 5. All results are listed in Table 2.

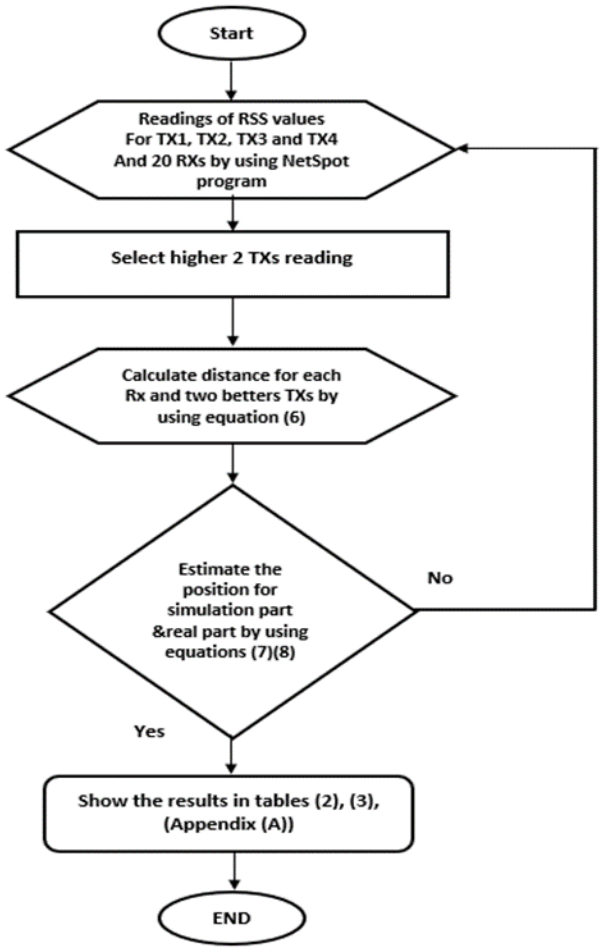

Fig. 5. The Steps to clarify work procedures

Table 2. The results of position estimation improvement in the simulation part of TX1&TX2&TX3&TX4

	TX1	TX2	TX3	TX4	first TX		second TX		Real		Estimate		Error coordinates	
RXs	RSS	RSS	RSS	RSS	d1(estim)	d1(real)	d2(estim)	d2(real)	x	y	x	y	x	y
RX1	-37.98	-44.24	-86.92	-102.82	2.476	2.8	24.89	25.33	8.031	0.107	8.32	0.15	0.297	0.048
RX2	-31.51	-40.72	-79.48	-94.87	0.794	1.11	21.88	22.28	10.04	0.786	10.29	0.85	0.251	0.067

RX3	-33.95	-41.56	-115.26	-85.56	3.892	4.224	18.22	18.78	12.36	7.027	12.63	7.496	0.26	0.46
RX4	-38.1	-46.01	-77.98	-76.08	9.018	9.48	12.68	13.34	15.95	40.41	16.07	40.96	0.122	0.546
RX5	-48.85	-48.2	-85.97	-77.61	15.33	15.85	6.688	7.17	20.14	32.61	19.99	32.78	0.154	0.17
RX6	-41.52	-32.69	-72.1	-94.98	19.82	20.32	2.432	2.76	23.11	6.952	22.84	7.157	0.26	0.205
RX7	-39.23	-35.66	-85.83	-89.07	23.96	24.32	1.582	1.939	25.76	0.516	25.52	0.522	0.238	0.006
RX8	-73.88	-38.7	-98.03	-61.35	6.698	7.193	19.87	20.48	9.496	8.830	8.997	7.329	0.499	0.500
RX9	-105.36	-54.49	-97.3	-52.51	12.10	12.99	14.19	14.72	15.22	15.60	14.46	14.07	0.758	1.532
RX10	-79.26	-49.3	-79.64	-46.29	17.78	18.35	8.732	9.195	20.65	36.18	18.93	35.49	1.716	0.693
RX11	-130.4	-60.33	-41.43	-40.32	24.79	25.20	2.653	3.059	27.17	0.157	28.62	0.194	0.455	0.037
RX12	-88.14	-88.2	-47.54	-46.7	18.37	19.16	2.775	3.199	20.20	8.405	19.86	8.163	0.33	0.241
RX13	-100.76	-78.96	-48.71	-42.32	14.34	14.90	6.71	7.278	16.42	36.61	15.70	34.95	1.125	1.659
RX14	-80.96	-77.45	-40.09	-56.04	9.260	9.82	12.14	12.70	10.97	20.17	9.301	21.91	1.27	0.257
RX15	-81.09	-87.11	-31.97	-46.76	3.851	4.167	17.64	18.11	12.34	7.140	11.62	6.950	0.714	0.190
RX16	-90.57	-83.73	-33.3	-39.69	1.044	1.401	20.89	21.28	10.26	1.096	11.50	1.362	0.236	0.266
RX17	-65.6	-98.66	-35.35	-47.58	3.002	3.359	24.87	25.35	7.60	0.005	8.892	0.12	1.286	0.114
RX18	-45.37	-91.13	-49.68	-82.87	19.01	19.46	7.174	8.07	21.59	28.55	19.02	28.50	0.578	0.047
RX19	-69.12	-98.38	-53.89	-94.95	13.87	14.52	12.16	12.95	14.28	12.62	15.79	11.69	1.491	0.927
RX20	-39.78	-80.89	-72.54	-106.56	6.963	7.359	19.09	20.06	7.35	7.965	7.461	8.815	0.109	0.850

Note that the range of error coordinates of TX1, TX2 are between (0.0114, 0.0472) to (1.2685, 2.3207), and (0.0429, 0.0608) to (2.4821, 11.0249) for TX3&TX4. While the range of error coordinates of proposed method which are listed in table 2 are between the range (0.1091, 0.0061) to (1.7162, 1.6593). The results show that a significant improvement in the error coordinate is achieved in the proposed method.

5.2. The Real measurements

To perform the experiment in real measurement, a hardware device was used to implement this experiment, as shown in Fig. 6.

In order to validate out proposed, real measurements are applied in the same case study building with a same procedure as in simulation part. The real measurement is investigated by personal computer (PC) with a NetSpot program that support the real reading of RSS for each RX received from each TXs, as indicated in Fig. 7.

So that, four measurements are corresponding to each RX, while are listed in Table 3 in columns of TX1, TX2, TX3, and TX4. Also, we complete the same procedure of simulation part in order to estimate each d1&d2 that used to determine the estimated location for each RX. In addition, a comparison is applied for each estimated value with the corresponding one to find the error coordinate. All those values for each RX are listed in the same line of RXs. Note that, the two red numbers of RSS values for each RX refers to the better two reading among for 4 values.

Fig. 6. The hardware device

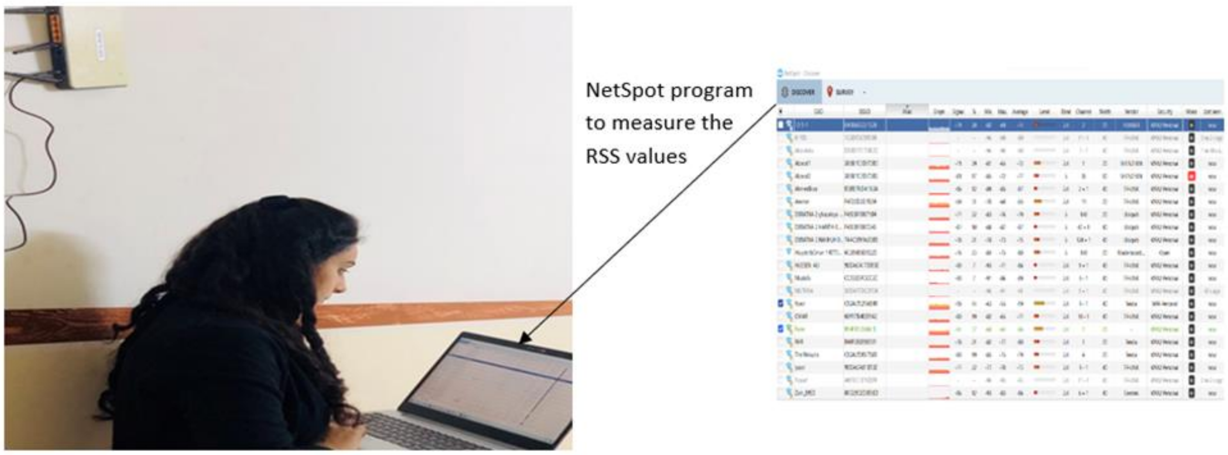

Fig. 7. The real measurements of RSS by using NetSpot program

Table 3. The results of position estimation improvement in the real part of TX1&TX2&TX3&TX4

	TX 1	TX 2	TX 3	TX 4	first TX		second TX		Real		Estimate		Error coordinates	
RXs	RSS	RSS	RSS	RSS	d1(estim)	d1(real)	d2(estim)	d2(real)	x	y	x	y	x	Y
RX1	-35	-54	-43	-89	2.443	2.8	24.91	25.33	20.90	3.645	20.09	3.57	0.816	0.07
RX2	-40	-59	-45	-88	0.706	1.11	21.82	22.28	15.04	3.756	14.22	3.597	0.826	0.15
RX3	-43	-62	-52	-86	3.791	4.22	18.26	18.78	8.26	6.753	7.593	6.290	0.670	0.46
RX4	-48	-52	-56	-81	9.000	9.48	12.81	13.34	15.95	38.41	16.02	39.82	0.070	0.407
RX5	-55	-47	-58	-79	15.34	15.89	6.695	7.174	20.14	32.61	19.99	32.81	0.154	0.20
RX6	-59	-40	-62	-75	19.72	20.32	2.362	2.765	23.11	6.952	22.79	7.18	0.316	0.23
RX7	-63	-34	-88	-72	23.69	24.32	1.596	1.939	25.76	0.516	25.33	0.847	0.423	0.33
RX8	-75	-45	-89	-70	6.442	7.193	20.03	20.48	11.89	8.536	12.008	8.168	0.117	0.36
RX9	-83	-47	-80	-65	12.52	12.99	14.06	14.72	16.22	26.61	16.32	27.05	0.101	1.440
RX10	-80	-56	-78	-57	17.78	18.35	8.621	9.195	20.65	40.18	20.50	39.86	0.153	0.324
RX11	-87	-50	-65	-39	24.69	25.20	2.662	3.059	26.17	5.709	25.83	5.786	0.335	0.076
RX12	-73	-71	-60	-40	18.55	19.16	2.797	3.199	22.20	8.405	21.89	8.687	0.303	0.282
RX13	-84	-75	-55	-42	14.35	14.90	6.85	7.278	19.42	36.61	19.27	37.31	0.15	0.698

RX14	-77	-79	-53	-45	9.29	9.826	12.244	12.70	15.97	10.57	15.99	10.33	0.019	0.844
RX15	-70	-85	-50	-55	3.66	4.167	17.55	18.11	12.343	7.14	12.57	7.348	0.233	0.207
RX16	-73	-87	-40	-59	0.995	1.401	20.68	21.28	10.26	1.09	10.62	1.248	0.35	0.152
RX17	-49	-86	-39	-63	2.962	3.359	24.95	25.35	20.8	4.227	20.06	4.077	0.737	0.150
RX18	-42	-85	-42	-70	19.04	19.46	7.649	8.07	19.18	25.36	18.77	24.82	0.407	0.53
RX19	-41	-89	-47	-77	14.04	14.52	12.47	12.95	7.74	12.25	7.674	12.44	0.066	0.80
RX20	-39	-83	-52	-80	6.83	7.359	19.53	20.06	8.82	9.55	8.263	8.950	0.559	0.608

From the results of Table 3, it is illustrated that the range of errors are between (0.0667, 0.0741) to (0.8162, 1.4402) Which is close to the range of error of simulation part.

6. Conclusions

In this paper, the hyperbolic method for indoor positioning system. Firstly, we used 2TXs, within two sided of building namely TX1&TX2 either TX1&TX2 and TX3&TX4, the results show that the range of error is between (0.149839, 0.03747) to (1.30367, 1.18358),) and (0.031236, 0.05480) to (1.546445, 3.59754) for each side respectively. To improve the error range, a proposed method is introduced in this paper, which included a selection of optimum 2 reading of RSS from 2TXs lying on a same side of the selected building. The result of the proposed method show that a significant improvement is achieved for positioning accuracy in the range of error between (0.0667, 0.0741) to (0.8162, 1.4402). To validate the proposed method, real measurements are applied in these experiments in order to show the benefits of proposed system. The result show that a good validation is achieve for the proposed method.

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Appendix (A)

Table 1A. The results of position estimation in the simulation part of TX1&TX2

	TX1			TX2			Real		estimate		Error coordinates	
RXs	RSS	d1(estim)	d1(real)	RSS	d2(estim)	d2(real)	x	y	x	y	X	Y
RX1	-30.7	1.7364	1.594	-46.42	26.332	26.987	7.724	0.107	8.219	0.384	0.495	0.277
RX2	-28.8	2.3645	2.509	-46.41	25.986	24.193	9.777	1.831	8.508	0.765	1.268	1.066
RX3	-38.9	5.6321	5.927	-37.81	21.356	20.571	12.447	9.437	11.939	7.610	0.508	1.827
RX4	-39.9	11.3697	11.409	-45.59	13.998	14.87	16.602	106.90	16.942	108.080	0.339	1.171
RX5	-47.3	17.1236	17.571	-37.21	7.321	8.609	21.156	39.624	21.226	38.528	0.069	1.095
RX6	-39.1	20.9634	21.935	-45.72	4.369	4.448	24.327	11.491	23.754	13.102	0.573	1.611
RX7	-47.3	26.3654	26.128	-29.96	2.012	1.21	27.402	0.911	27.540	1.576	0.138	0.664
RX8	-74.2	27.9852	28.171	-41.44	6.325	6.799	28.327	5.798	28.268	5.334	0.059	0.464
RX9	-93.5	30.3321	30.047	-39.19	12.789	12.647	28.264	13.55	28.455	13.307	0.190	0.251
RX10	-99.2	32.1236	32.852	-45.82	17.998	18.288	28.291	21.723	27.776	22.854	0.515	1.130
RX11	-117	37.9896	37.696	-49.47	25.364	25.97	28.316	33.85	29.062	33.203	0.745	0.654
RX12	-94.8	33.2136	33.617	-101.45	26.354	26.539	23.830	62.854	23.589	63.959	0.240	1.105
RX13	-88.5	30.2315	31.053	-103.08	26.049	27.569	20.731	132.475	21.166	130.154	0.435	2.320
RX14	-102	28.2364	28.618	-82.64	27.976	29.786	16.920	100.078	18.079	101.950	1.158	1.871
RX15	-83.4	27.5463	26.709	-94.69	33.321	32.815	12.791	41.146	12.958	40.814	0.166	0.332
RX16	-83.8	26.6654	26.166	-94.68	34.321	34.804	10.509	20.815	11.344	21.805	0.835	0.990
RX17	-49.1	25.3321	25.851	-100.79	37.946	37.528	7.524	9.066	6.711	6.987	0.812	2.078
RX18	-43.3	19.2365	19.294	-87.06	33.136	33.158	7.704	6.603	7.69	6.556	0.011	0.047
RX19	-47.7	14.4462	14.523	-116.61	30.785	30.615	7.716	4.629	7.53	4.340	0.177	0.288
RX20	-43.5	7.6532	7.062	-82.84	26.564	27.816	7.751	1.864	8.824	3.189	1.073	1.324

Table 2A. The results of position estimation in the simulation part of TX3&TX4

	TX3			TX4			Real		estimate		Error coordinates	
RXs	RSS	d1(estim)	d1(real)	RSS	d2(estim)	d2(real)	x	y	x	y	x	y
RX1	-43.2	25.873	26.039	-99.76	38.071	39.069	7.940	10.55	7.043	7.960	0.89	2.59
RX2	-80.6	25.338	26.237	-99.07	35.982	36.973	10.166	18.575	9.82	17.69	0.340	0.87
RX3	-103.79	24.892	27.106	-102.59	33.158	34.395	13.18	41.72	12.77	34.12	0.413	7.59
RX4	-89.55	28.273	29.16	-104.15	29.339	30.803	17.77	41.56	17.28	30.54	0.486	11.02
RX5	-100.58	31.131	32.264	-79.99	26.937	27.73	22.63	128.87	22.25	118.91	0.373	9.965
RX6	-96.45	34.273	35.239	-84.11	25.744	26.597	26.07	65.50	25.77	65.04	0.294	0.459
RX7	-108.69	37.049	38.086	-45.26	25.183	25.628	29.47	42.33	28.74	39.87	0.725	2.456
RX8	-95	34.70	35.66	-43.67	19.783	20.253	30.36	29.45	29.72	28.16	0.633	1.285
RX9	-95.79	31.732	32.686	-53.86	13.943	14.48	30.32	20.23	29.71	19.47	0.605	0.757
RX10	-93.6	29.598	30.53	-38.22	8.028	8.861	30.25	12.12	29.30	11.29	0.949	0.829
RX11	-65.2	28.56	29.217	-33.06	1.286	1.622	30.22	3.020	27.74	0.68	2.482	2.329
RX12	-41.49	22.765	23.179	-37.21	6.836	7.216	25.42	22.92	25.24	22.86	0.17	0.060
RX13	-37.21	18.59	18.931	-41.4	11.087	11.501	22.02	67.96	21.98	66.90	0.042	1.05
RX14	-47.62	13.17	13.65	-55.28	16.210	16.764	17.82	155.90	17.75	150.79	0.07	5.11
RX15	-38.6	7.841	8.168	-41.61	21.872	22.296	13.42	15.41	13.24	15.009	0.17	0.40
RX16	-37.53	4.548	4.921	-45.56	25.202	25.666	10.744	4.976	10.48	4.783	0.262	0.192
RX17	-29.55	1.414	1.713	-52.34	29.018	29.542	7.65	0.69	7.26	0.41	0.38	1.106
RX18	-45.27	7.64	8.087	-94.79	29.324	30.321	7.866	2.872	7.179	2.325	0.687	0.547
RX19	-40.24	12.370	12.773	-100.03	30.812	31.815	7.931	4.711	7.24	3.854	0.69	0.857
RX20	-43.32	19.793	20.257	-104.46	34.412	35.447	7.969	7.955	7.26	6.57	0.70	1.38