Development of An Indoor Location System Based on Wi-Fi Using Artificial Intelligence Methods

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Abstract:

Indoor placement in enclosed spaces has been an ***increasing demand in recent years, and this research aims to provide a solution utilising current gear. This method, which relies on satellite communication to locate a device in open space and is widely used, doesn't work inside. It's a well-known statistic for determining the distance between wireless nodes by measuring signal intensity. There are a slew of environmental factors that might impact the signal strength, leading to inaccurate readings. An artificial neural network may be fed data on the transmission strengths of signals received from several transmitters inside a defined restricted area using the newly proposed method. The trained neural network's outputs have been shown to be significantly more successful and trustworthy than the path-loss calculation's outputs in the past.***

INTRODUCTION:

Wireless sensor networks are becoming more common in real-world applications and are employed in a broad range of industries. It is possible to use them in a wide range of applications, from site security and assisted living to home automation and health monitoring. There is a need for a solution to the indoor location challenge in a variety of industries. Generally speaking, the placement issue may be broken down into two sections. An open-field positioning system is one that utilises the Global Positioning System (GPS) to provide accurate results. Thus, a moving object's location and speed may be monitored in an open region. Moving nodes may be tracked using GSM and UMTS networks, which are supported by GPS. As an example, while a mobile phone user is connecting with GSM base stations, a user's signal strength may be utilised to determine the distance, direction, and speed of an item that is moving. The triangulation method may be used to forecast the user's location since the base station locations are well-known. A user's location may be determined directly from the GPS satellites if they are in communication with their smartphone and the GPS capability is available on that device. However, the GPS device costs a lot of money and cannot be utilised in locations that are covered. The use of GPS in confined area positioning systems is not practical, hence other methods must be used. The received signal intensity may be assessed if the transmission power is kept constant. In terms of cost, this strategy is the most efficient one. Because measuring signal strength does not need the installation of additional devices. Techniques such as time of arrival (TOA), angle of arrival (AOA), time difference (TDOA) and received signal strength (RSS) are employed for indoor locating in literature studied. It is possible to set up wireless positioning systems in one of two ways. Mobile aided and network assisted are two different methods. In the mobile aided strategy, the mobile node attempts to identify the nodes it can connect with in the vicinity of its current location. As part of the network-assisted technique, the central processing unit takes measurements of signals from mobile nodes and transmits them to a reference node for transmission to the central processing unit. Numerous papers have been written on the topic of wireless network placement. Results of established estimating techniques were evaluated by Hara and Anzai [1]. RSSI provides benefits over TDoA in a congested environment where the line of sight between the nodes is often disrupted, according to the results given The ITU indoor model was designed by Chrysikos at al. [2] for a particular venue. [3] Türkoral at al. devised a distance estimate technique for two nodes based on RSSI metrics, and they used three alternative transmission models for each node. They claim that a new algorithm for localization has been developed that includes an error-checking and repair approach. The RSSI-based fingerprint feature vector approach proposed by Zhang et al. [5] divides the covered area into grids and deploys access points. Several RSSI-based localization algorithms for wireless sensor networks and indoor-outdoor applications were tested in a survey study conducted by Mistry & Mistry [6]. Livinsa and Jayashri [7] provide an RSSI-based localization technique for improved indoor location distance prediction. As a result of employing varying number of anchor nodes, they were able to get the best distance estimate for outdoor environments and the lowest localization error. An technique based on RSSIS was proposed by Vadivukkarasi and Kumar [8]. Since GPS cannot be utilised in confined area locating systems, other methods must be used. The received signal intensity may be assessed if the transmission power is kept constant. 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They had better distance estimation for outdoor environment than indoor environment and achieved minimum localization error by using different number of anchor nodes. According to Vadivukkarasi and Kumar [8,] an RSSI-based strategy might be used

POSITION ESTIMATION ALGORITHMS:

It is necessary to communicate with at least three stations concurrently in order to estimate the coordinates of a node in a 2-D field. The next sections provide an overview of the WCL and Trilateration algorithms, both of which were spawned from this concept. Path Loss Modeling A When a radio signal travels over space, it loses some of its power density, and this drop in power density may be expressed as a reduction in dB (decibels) in path loss [13].

$$L = 10 \cdot \log(P_{tx}/P_{rx}) \quad (1)$$

Where L denotes the route loss in dB, the transmission power of the transmit unit in Watts, and the residual received signal power at the receiver. When the route loss model is adopted, Equation 2 can be utilised to calculate RSSI easily [14].

$$RSSI = -(10n\, log_{10} d + A) \quad (2)$$

where A is the received signal intensity at a distance of one metre and d is the distance from the signal transmitter, and n is the signal transmission exponent or constant. B. Centroid Localization Weighted Simply by calculating the average of the coordinates transmitted by each transmitter antenna, the Centroid Localization (CL) technique can estimate unknown node positions [6]. [15] is the algorithm's mathematical representation.

$$P_i^{CL}(x,y) = (1/n)\sum_{j=1}^{n} B_j(x,y) \quad (3)$$

where is the estimated coordinates of the node, is the exact coordinates of the beacon where the beacons are the

The number of antennas that broadcast their own coordinates, and the number of access points that receive their coordinates from the node.

C. Trilateration

Consider a wireless node P with an unknown location (p_x, p_y) and three access points A, B and C, known as the positions (a_x, a_y), (b_x, b_y) and (c_x, c_y), respectively. If we know the coordinates of the all three access points A, B and C we can calculate the exact position of node P. Figure 1 depicts the problem clearly.

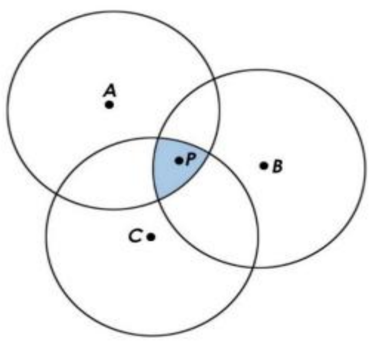

Fig. 1. Location calculation of the coordinate unknown wi-fi node with three access points.

Node's coordinates are determined by the distances, and, from the node to the access points A, B, and C. A set of equations [13] may be developed based on how far the node is from each of the three nearby wi-fi access points:

$$(p_x - a_x)^2 + (p_y - a_y)^2 - d_a^2 = 0 \quad (4)$$
$$(p_x - b_x)^2 + (p_y - b_y)^2 - d_b^2 = 0 \quad (5)$$
$$(p_x - c_x)^2 + (p_y - c_y)^2 - d_c^2 = 0 \quad (6)$$

INDOOR LOCATION POSITIONING APPLICATION:

A 4-meter-wide and 15-meter long conference room was selected as the indoor positioning application in this investigation. A total of six wi-fi access points have been strategically placed throughout the conference area. It is possible to connect to many wi-fi networks from a single wi-fi device. Wi-fi access points and a floor plan of the conference space are shown in Fig. 2.

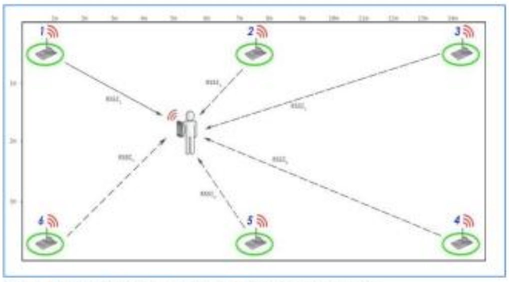

Fig. 2. Testbed for indoor location estimation experiment.

As seen in Figure 3, a web service is used to record the signal strength of various wi-fi sites. Four buttons on the meter's left side are used by the person who is going to take the measurements to input a specific measurement location. Data collection and transmission are monitored on an OLED display. The wi-fi signal strength of the gadgets in the room is measured and sent to the computer connected to the network by the measurement equipment. There are one-meter gaps between each measurement and recording session. Thereby, all wi-fi devices' fingerprint data and a map of their signal strength are gathered.

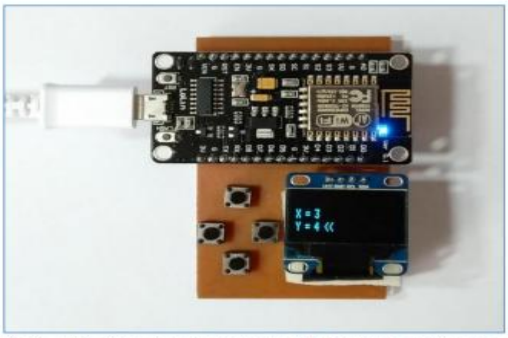

Fig. 3. wi-fi signal strength measurement device which consists of a NodeMCU development board and an OLED display.

Wi-Fi devices can monitor RSSI values between -95 dBm and 0 dBm. For the sake of clarity and convenience of use, all measurement values have been multiplied by a factor of 100. The main issue with RSSI-based motion monitoring is that it is very susceptible to changes in the surrounding environment. Precision and accuracy in prediction were limited by RSSI measurement's diminishing accuracy. The RSSI measuring technique is unreliable because even if the sending and receiving devices have not moved, there may be variations in the signal intensity. As shown in Figure 4, the scatter plot tool in Matlab was used to display the RSSI values for each node.

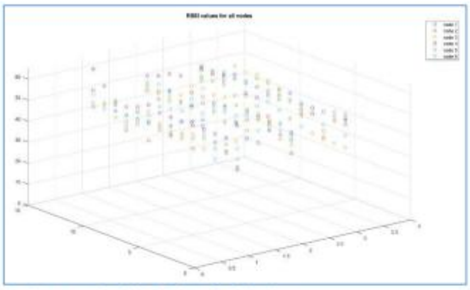

Fig. 4. Scatter plot of RSSI values for all nodes.

When the number of nodes in a scatter plot rises, the graphic becomes unreadable. Use of heat maps helped to make the data more understandable. RSSI signal intensity maps are shown in Figure 5 and Figure 6 for station 1 and station 2, respectively.

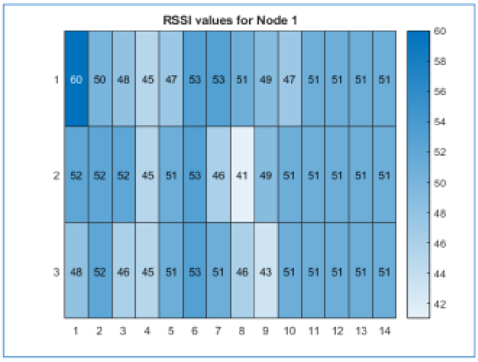

Fig. 5. RSSI heat-map presentation for wi-fi node 1, which is located in a (3m by 14m) room.

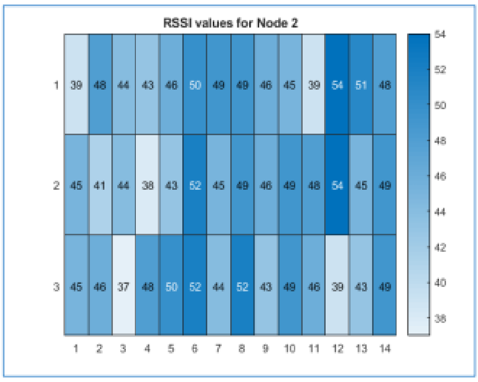

Fig. 6. RSSI heat-map presentation for wi-fi node 2, which is located in a (3m by 14m) room.

DEVELOPING AN ANN FOR WI-FI FINGERPRINTING METHOD

As shown in Figures 5 and Figure 6, The RSSI readings do not follow a normal distribution. The validity of equation 1 is lowered in this circumstance. In other words, determining the distance between two nodes only based on the intensity of the signal is very challenging. The wi-fi fingerprint approach was used to create an artificial neural network as a solution to this issue. The nodes' RSSI levels are sent into an artificial neural network, and the output is the location of the measurement instrument. Created artificial neural network model using Matlab's Neural Network tool. Fig. 6 depicts the artificial neural network's structure. As a result, the hidden layer of the network comprises 20 neurons and 6 inputs, 2 outputs. We used Leven berd-Marquardt training and randomly segmented data for our experiment. Network performance was evaluated using the Mean Square Error (MSE) metric [16]. Formula 7 provides the MSE estimate for back propagation efficiency

$$MSE = \frac{1}{N}\sum_{i=0}^{N}\sqrt{(x-\hat{x})^2+(y-\hat{y})^2} \qquad (7)$$

Figure 7, depicts main architecture of the developed artificial neural network.

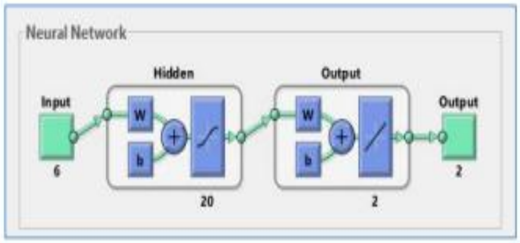

Fig. 7. Architecture of the developed artificial neural network.

Data collected for training, testing, and validation comprised 70% of the total obtained data. There are a total of 103 measurements in the whole set. To confirm the accuracy of the data, at least two measurements were taken at each location. The MSE error graph, shown in Figure 8, was generated throughout the training period.

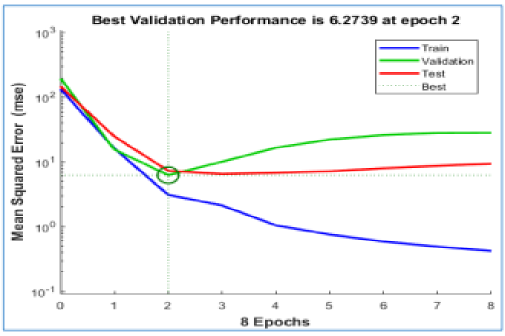

Fig. 8. MSE values for training, validation and test process.

Figure 9 shows the trained network's error histogram. There is a uniform distribution of error histogram data. There is no build up on either side of the road.

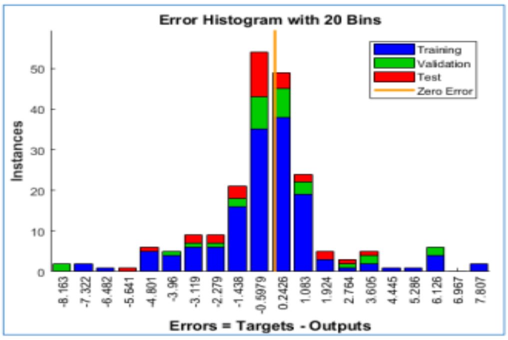

Fig. 9. Error histogram for the trained ANN outputs.

CONCLUSION:

Figure 10 displays the validity and test results of schooling. As a result, the trained network's average performance was determined to be 0.87. In this case, the aim is to achieve a value of 1. However, even at the same location, multiple RSSI values are measured, and the findings are distorted when these numbers are used for instruction. When compared to the logarithmic calculation technique, the created model provides more accurate findings.

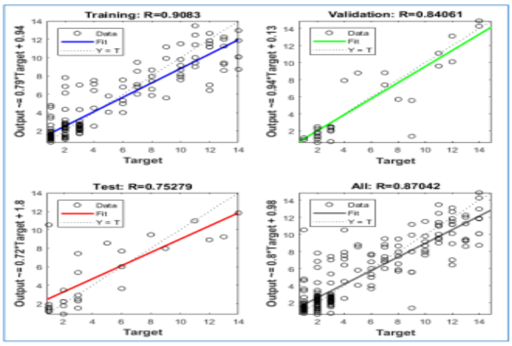

Fig. 10. Training, validation and test performance graphics for the trained ANN.

More wi-fi nodes may be added, or the artificial neural network can be re-trained with new parameters in order to improve the application's sharpness. The acquisition of RSSI data may be smoothed using several ways. An artificial intelligence technology known as neural network fingerprinting is used in this research to examine the use of RSSI data. In addition, a new measuring method for indoor positioning has been developed that does not need additional equipment and does not incur additional energy expenses. Future research will be encouraged by these findings.

REFERENCES :

[1] S. Hara and D. Anzai, “Experimental Performance Comparison of RSSI- and TDOA-Based Location Estimation Methods,” in VTC Spring 2008 - IEEE Vehicular Technology Conference, 2008, pp. 2651–2655.

[2] T. Chrysikos, G. Georgopoulos, and S. Kotsopoulos, “Sitespecific validation of ITU indoor path loss model at 2.4 GHz,” in 2009 IEEE International Symposium on a World of Wireless, Mobile and Multimedia Networks Workshops, 2009, pp. 1–6.

[3] T. Türkoral, Ö. Tamer, S. Yetiş, E. İnanç, and L. Çetin, “Short Range Indoor Distance Estimation by Using RSSI Metric,” Istanb. Univ. - J. Electr. Electron. Eng., vol. 17, no. 2, pp. 3295–3302. [4]

[4] B. Guan and X. Li, “An RSSI-based Wireless Sensor Network Localization Algorithm with Error Checking and Correction,” Int. J. Online Eng. IJOE, vol. 13, no. 12, p. 52, Dec. 2017.

[5] A. Zhang, Y. Yuan, Q. Wu, S. Zhu, and J. Deng, “Wireless Localization Based on RSSI Fingerprint Feature Vector,” Int. J. Distrib. Sens. Netw., vol. 2015, pp. 1–7, 2015.

[6] H. P. Mistry and N. H. Mistry, “RSSI Based Localization Scheme in Wireless Sensor Networks: A Survey,” in 2015 Fifth International Conference on Advanced Computing Communication Technologies, 2015, pp. 647–652.

[7] Z. M. Livinsa and S. Jayashri, “Performance analysis of diverse environment based on RSSI localization algorithms in wsns,” in 2013 IEEE Conference on Information Communication Technologies, 2013, pp. 572–576.

[8] K. Vadivukkarasi and R. Kumar, “A New Approach for Error Reduction in Localization for Wireless Sensor Networks,” 2012.

[9] Y. Chen, L. Zhang, and J. Wang, “Localization indoor patient in wireless sensor networks,” in 2013 First International Symposium on Future Information and Communication Technologies for Ubiquitous HealthCare (Ubi-HealthTech), 2013, pp. 1–3.

[10] A. Mesmoudi, M. Feham, and N. Labraoui, “Wireless Sensor Networks Localization Algorithms: A Comprehensive Survey,” Int. J. Comput. Netw. Commun., vol. 5, no. 6, pp. 45–64, Nov. 2013.

[11] A. T. Parameswaran, M. I. Husain, S. Upadhyaya, and others, “Is rssi a reliable parameter in sensor localization algorithms: An experimental study,” in Field Failure Data Analysis Workshop (F2DA09), 2009, p. 5.

[12] A. Kuntal, M. L. Tetarwal, and P. Karmakar, "A Review of Location Detection Techniques in Wi-Fi," 2014.

[13] F. İleri and M. Akar, "RSSI Based Position Estimation in ZigBee Sensor Networks," Signal Process. Commun., p. 12.

[14] A. Paul and T. Sato, "Localization in Wireless Sensor Networks: A Survey on Algorithms, Measurement Techniques, Applications and Challenges," J. Sens. Actuator Netw., vol. 6, no. 4, p. 24, Oct. 2017.

[15] N. Bulusu, J. Heidemann, and D. Estrin, "GPS-less low-cost outdoor localization for very small devices," IEEE Pers. Commun., vol. 7, no. 5, pp. 28–34, Oct. 2000.

[16] M. Duhan, "Study of Localisation Methods of Mobile Users in Wireless Sensor Networks," vol. 3, no. 6, p. 6, 2014.

[17] İ. Kırbaşand A. Kerem, "Short-Term Wind Speed Prediction Based on Artificial Neural Network Models," Meas. Control, vol. 49, no. 6, Jul. 2016