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THE IMPLEMENTATION OF INDOOR CHILD MONITORING SYSTEM USING TRILATERATION APPROACH

Normazatul Shakira Darmawati and Nurul Hazlina Noordin
Faculty of Electrical & Electronics Engineering, Universiti Malaysia Pahang, Pekan, Pahang, Malaysia
E-Mail: normazatulshakira@yahoo.com

ABSTRACT

This paper presents the child monitoring system by implementing one of the indoor positioning techniques. Over the years, there have been numerous reports on missing children in crowded areas such as in shopping complexes. One of the reasons is the difficulty to monitor these children and this demands a system that could enable parents to track their children's whereabouts. Unlike outdoor monitoring system which makes use of the GPS signals, indoor positioning system makes use of the Wi-Fi signals. The aim of this project is to implement an Indoor Positioning System that is able locate their child in a confined space as Global Positioning System are limited to outdoor tracking. The proposed system will be based on Wi-Fi signal strength that uses trilateration technique to calculate the exact location of the child. . The proposed system uses three access points and the strength of the WI-FI signals at each access points is used in order to calculate the position of the children. The system is implemented using Intel Galileo Development board. The measured results of the proposed system achieved 90% accuracy.

Keywords: trilateration, received signal strength, matlab GUI, and intel galileo gen 2 board.

INTRODUCTION

Improvement of systems and solutions for solving the problem of indoor positioning is a promising and a complex task. This problem requires of creating maps based on floor plans indoors, deploying the appropriate positioning devices inside buildings, choosing the effective positioning techniques and algorithms. There are variety of indoor positioning techniques using radio signal based approaches for localization such as Bluetooth, Wi-Fi, signals of cellular towers, ZigBee and others. The methods using Wi-Fi signal strength are more preferred because Wi-Fi networks are prevalent in most public buildings and it don't requires an additional infrastructure and allows determine a location of each user of mobile device [1].

To date, there are numerous indoor positioning algorithms that are based on Wi-Fi trilateration approach. Trilateration is one of them that determine absolute or relative locations by measurement of distances. This method uses three fixed points, also known as access points, to determine the position. The distance can be provided by using measured signal techniques as received signal strength (RSS), time of arrival of radio signals from transmitters (ToA) or time difference of arrival of several radio signals (TDoA).

The main idea is the calculating distances between access points (AP) and receiver to provide an area of localization. Similar approaches are based on triangulation method and using measurement of arriving signal angle.

RELATED WORKS

Indoor positioning system is a modular system used to track and locate persons or objects inside buildings [2]. G. Buckberry from Siemens Communications stated that indoor location is crucial nowadays and Wi-Fi networks are useful as it is the basics idea of the location process. One method which is the focus of much research is to use the signal strength received from Wi-Fi access points. Besides that, Wi-Fi networks becoming much more common and the received signal strength is available as part of the networking statistics are the advantages of the systems.

This means that specialist equipment is not required to provide location information. The location information is found by mapping position estimates to location areas. Multilateration estimates the position of the device of interest by using the strength of signals received from several non-collocated, non-collinear transmitters. Using the relationship between signal strength and distance given, an estimate of the distance between the device and each transmitter can be obtained.

METHODOLOGY

Trilateration techniques uses only distance to estimate the position of the user in a bi-dimensional plane. This technique requires the distance between the receiver and transmitter to be measured. This can be done using a Received Signal Strength Indicator (RSSI) which is transmitted from the access points.

For the indoor location system 2D trilateration is used to find an object that is located on a surface, which will be on an XY plane. The location of three access points has to be known along with the distances between the readers and the unknown object for 2D trilateration to work correctly.

Xi and Yi represent the position of A_i (readers) where i = 1, 2, 3

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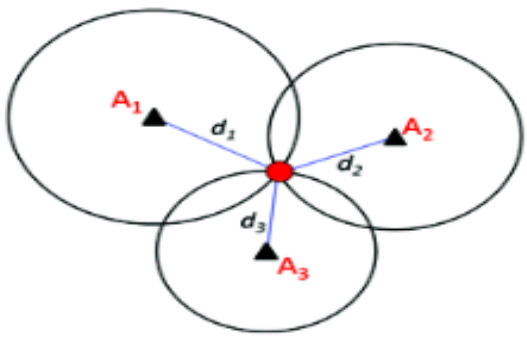

Figure-1. Trilateration method with red dot in the center has an unknown location.

The signal strength between the user and the access points is converted into distance by using an equation:

$$d_i = p(1 - m_i) \quad (1)$$

where :

d = distance

m = the percentage of signal strength received

p = the maximum coverage of signal strength transmit

i = number of access points used

Using the trilateration concept, the location of the children is then calculated using Equation 2(a), 2(b) and 2(c).

$$(x - x_1)^2 + (y - y_1)^2 = d_1^2$$
$$(x - x_2)^2 + (y - y_2)^2 = d_2^2$$
$$(x - x_3)^2 + (y - y_3)^2 = d_3^2 \quad (2)$$

By solving the equation using Cramer's Rule, we can identify the user location to find the X and Y coordinates

$$x = \frac{\begin{vmatrix} (d_1^2 - d_3^2) - (x_1^2 - x_3^2) - (y_1^2 - y_3^2) & 2(y_3 - y_1)y \\ (d_2^2 - d_3^2) - (x_2^2 - x_3^2) - (y_2^2 - y_3^2) & 2(y_3 - y_2)y \end{vmatrix}}{\begin{vmatrix} 2(x_3 - x_1)x & 2(y_3 - y_1)y \\ 2(x_3 - x_2)x & 2(y_3 - y_2)y \end{vmatrix}} \quad (3)$$

$$y = \frac{\begin{vmatrix} 2(x_3 - x_1)x & (d_1^2 - d_3^2) - (x_1^2 - x_3^2) - (y_1^2 - y_3^2) \\ 2(x_3 - x_2)x & (d_2^2 - d_3^2) - (x_2^2 - x_3^2) - (y_2^2 - y_3^2) \end{vmatrix}}{\begin{vmatrix} 2(x_3 - x_1)x & 2(y_3 - y_1)y \\ 2(x_3 - x_2)x & 2(y_3 - y_2)y \end{vmatrix}} \quad (4)$$

EXPERIMENTAL SETUP

The trilateration concept is then implemented on Intel Galileo Development Board. The process is described in this section. The coordinates of the Location 1 is described as follows:-

Location 1:
AP1 = (10, 4)
AP2 = (1, 1)
AP3 = (10, 10)

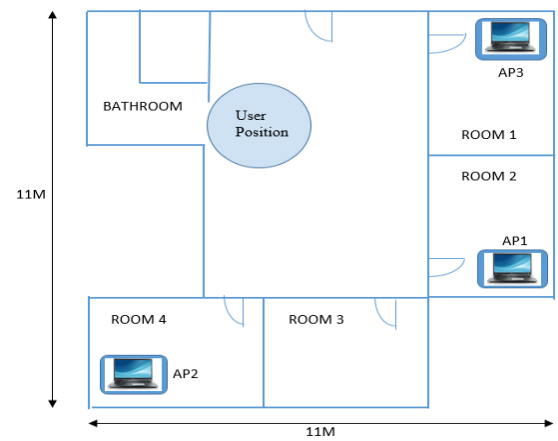

Figure-2. Application scenario at location 1.

Note that as for Location 1, hotspot from laptop is used as Wi-Fi router that acts as a transmitter to propagate the signal to the receiver.

Block diagram illustrated in Figure-3 shows the data flow from antenna (receiver) to the processor (MATLAB). The hardware acts as receiver to this system, which will then be key in MATLAB GUI to calculate the user position. This signal strength must convert into distance before being calculated using trilateration techniques.

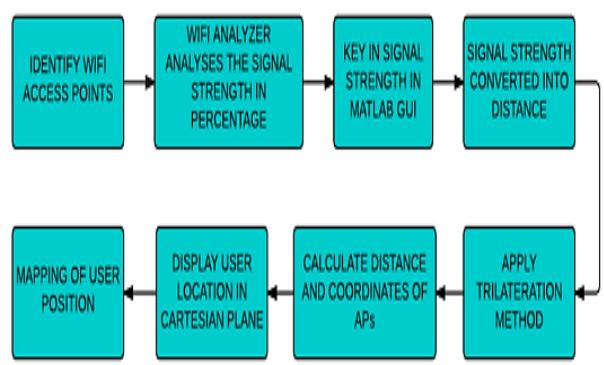

Figure-3. Block diagram of the project.

In this project, user will carry the hardware of Intel Centrino Wireless Card together with Intel Galileo Gen 2 Board. This hardware is used to scan the received signal strength available in that area.

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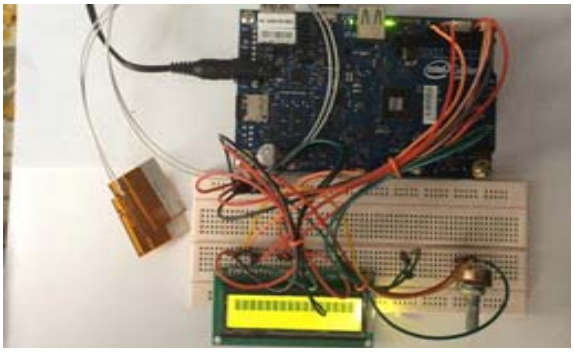

Figure-4a. Intel galileo gen 2 board with wireless card and LCD.

Figure-4b. Wireless card starts scanning Wi-Fi networks available.

Based on Figure 4a and 4b, once the hardware start scanning the available networks in that area, the result of Wi-Fi signal strength in percentage will be display in a serial monitor. These results will be used to calculate the position of the child.

RESULT AND DISCUSSION

The data location consist of the estimate user position are being recorded at one of the room at UMP Pekan residential. The hardware is being setup and the readings of the location are recorded.

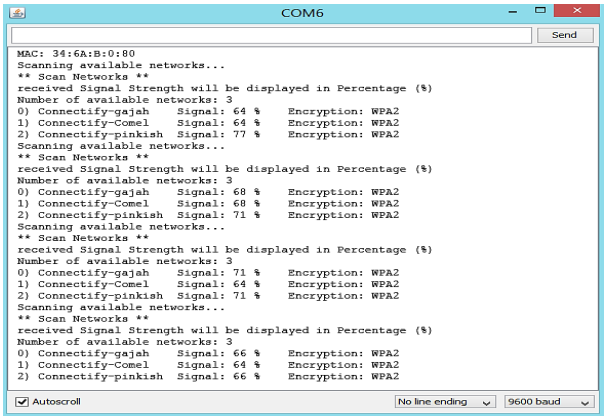

Figure-5. Example reading from the serial monitor at location 1.

Ten data from each of signal strength received in Figure-5 are recorded in Table-1.

Table-1. Data collected from UMP residential area.

Readings	Wi-Fi Signal Strength at Access Points in Percentage (%)		
	AP 1	AP 2	AP 3
1	64	64	77
2	68	68	71
3	71	64	71
4	66	64	66
5	66	60	66
6	62	64	64
7	64	62	71
8	64	55	71
9	68	48	73
10	71	53	66

Based on Table-1, the strength of the Wi-Fi signal varies and this is commonly due to the changes in the transmitted radiation pattern of the transmitter.

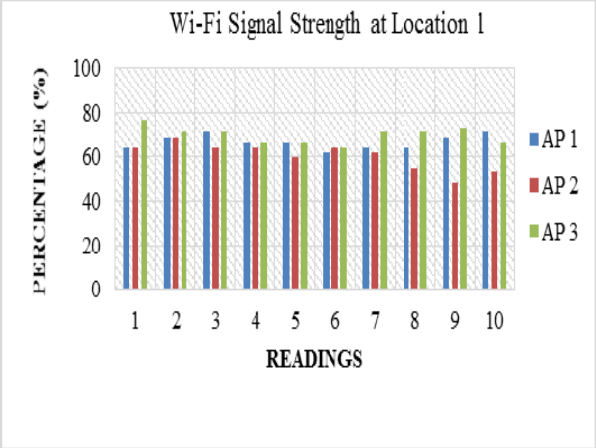

Figure-6. Signal strength chart of UMP's Pekan room.

As shown in Figure 6, the signal strength received at AP2, for the 8th and 9th iteration, drop about 10% while signal reading for AP3 and AP1 overall shows constant high value.

To get the estimate position of the user in (x, y) coordinates, calculation using Matlab GUI is made for every readings collected as shown in appendix. The average of the signal strength taken is calculated to get the accurate user position in a Cartesian plane and real floor mapping.

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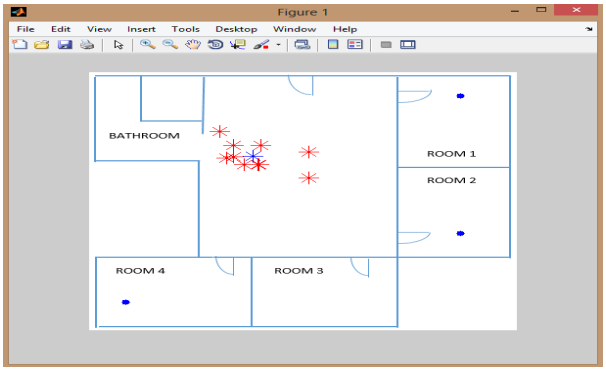

Figure-7. Mapping of user position for all readings at location 1.

Figure-7 shows the plot of the results for ten iterations. The red star from figure above indicates the user location from 10 readings, while blue star shows the average result of user position which is the accurate user position. The blue dot indicates the access points located in this location which are at (10, 4) for AP1, (1, 1) for AP2 and (10, 10) for AP3. The access points are randomly placed and hotspot from laptop is used as a Wi-Fi router.

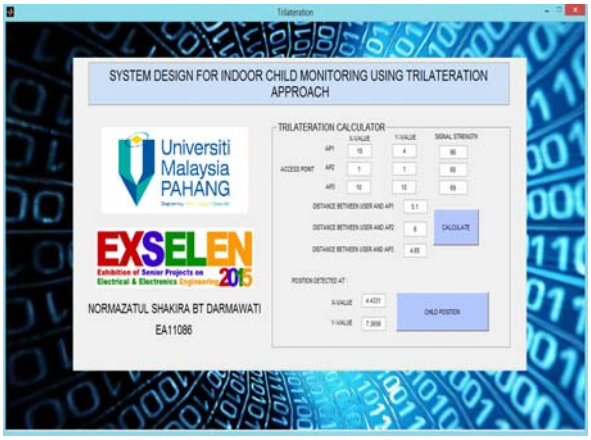

Figure-8. MATLAB GUI for trilateration technique at location 1.

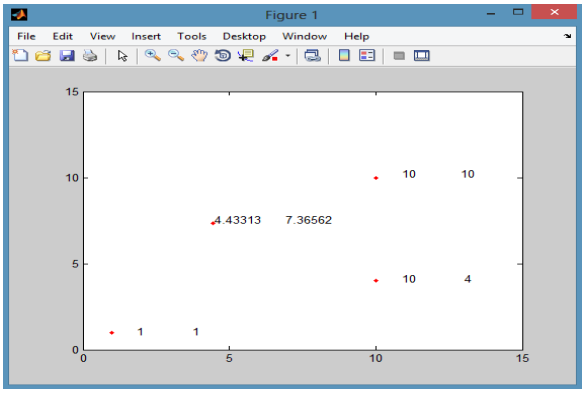

Figure-9. User location in a 2D Cartesian plane at location 1.

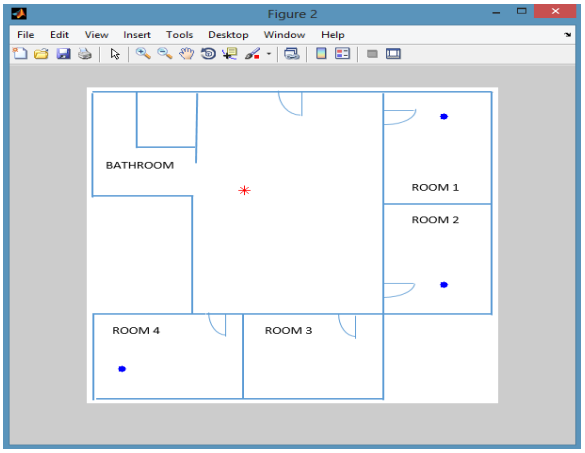

Figure-10. Average user position in a real floor mapping of location 1.

Details of data need to key in into GUI using MATLAB are shown in Figure-8. The real coordinates in a 2D Cartesian plane from the average reading as shown in Figure-9. In a real floor mapping it is true that the user are collecting the data near the bathroom and 2 meters from front door as displayed in Figure-10.

CONCLUSIONS

Trilateration technique was shown to effectively detect user in indoor vicinity as we can finally detect the user location and make a real floor mapping from the data receiver. With the aid of GUI in MATLAB, the process of finding the exact coordinates of user position can be easily determine by plotting the coordinates in Cartesian plane.

Last but not least, all parents want to protect their children, keep them safe and hopefully this child tracking system can help assists parents in securing life's most precious assets and reduce the percentage of missing child in Malaysia.

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