SCOPUS-2017-CONF-IEEE-Mobile-robot positioning for Wi-Fi signal

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Mobile-Robot Positioning for Wi-Fi Signal Strength Measurement

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***Abstract*— The aim of this work is to design a mobile robot using WPT (Wi-Fi Position Techniques) method. The design in this research is intended to determine the mobile robot position by using the Wi-Fi module to determine the coordinates of position as determination to reach the target position and to find the strength of the detected Wi-Fi signal. Mobile robot is using to get the results of the strength of the signal, besides mobile robot can also be applied for various purposes, such as potential for localization and navigation purposes in areas hard to reach by humans. The proposed method does not require the environment layout and additional equipment**

Keywords*— Access Point; Mobile Robot; WPT (Wi-Fi Position Techniques)

I. Introduction

Over the past decade, robot localization and tracking in indoor environments has been a lot of progress in the robotics society. The purpose of localization is to estimate position and orientation of a mobile system with aspect to its environment. This is called global localization, if there is no priori estimate of position and direction [1].

Global Positioning System (GPS) can provide accuracy and reliable positioning information, rapidly explore unknown areas [2]. However GPS cannot be used effectively in an indoor environment, because the required satellite links are blocked or unreliable inside buildings [3].

In overcoming these shortcomings, to identify indoor locations is using many existing sensors, such as ultrasonic sensors, infrared, magnetic, and radio [4]. However, it is requires permanent electronic infrastructure to facilitate the measurement, and requires special sensors or actuators to simplify localization.

Indoor Positioning Systems (IPS) are techniques used to obtain the position of person or objects inside a building [5]. The real word applications depending on such automation are many, such as location detection of firemen in a building on fire, detecting the location of police dogs trained to find explosives in a building, and finding mobile phone that is still active on the plane [6].

There are several types of wireless technology used for indoor locations i.e. GPS-Based, RFID, Cellular-Based, UWB, Bluetooth (IEEE 802.15) and WLAN [6]. GPS-based is the most successful technology in determining the position in the outdoor environment [2]. However, coverage is poor satellite signal to the indoor environment lowers its accuracy and make it unsuitable for indoor location. System LANDMARC was used indoor location sensing using active RFID, approach requires signal strength information from each tag to readers [7].

A number of systems have used the mobile network multiple division access (GSM / CDMA) to find the location of the outdoor mobile client. But general, the accuracy is higher in closed (eg, urban) and reduced signal in rural environments [8]. UWB is based on the transmission of ultrashort pulses. Different with conventional RFID systems, which is operate on a single band. UWB tags are less consuming strength over conventional RF and can operate broadly spectrum radio [9][10].

WLAN is infrastructure for indoor location, by adding a location. The accuracy of typical WLAN positioning systems using received signal strength is approximately 3 to 30 m, with an update rate in the range of few seconds. Wireless location sensing is actually a special problem in mobile robotics, the robot localization determining the position of the robot move by inputs from various sensor [11].

Therefore, WLAN is feasible and practicable seen as a convenient position determination technique for indoor environments, or in application downtown urban areas, wherever WLAN is deployed. One of them, Wi-Fi Positioning Systems (WPS) [12][13] are those based on portable devices, such as mobile phones, to locate people or objects by measuring the level of the signal received from different access points (APs), that is, Wi-Fi routers. Wireless Positioning System (WPS) is an existing wireless infrastructure facility such as IEEE 802.11 Wi-Fi signal to estimate the location of mobile users.

Wireless Positioning System is as the identification of the position and direction in determining the location of a mobile

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phone user. It is useful in place of public facilities, such as airports, roads, office buildings, shopping center, and, usually have a lot AP hot spots, which are a wide range of Wi-Fi networks [5].

Wi-Fi-based indoor localization has been attractive due to its open access and low cost properties [14]. However, the strength of the received signal based distance is influenced by temporal and spatial variations due to the multipath effect [15]. Environmental factors that affect Wi-Fi Signals such as Walls, windows and doors, and other objects even the movement of people

In this research, we present the design and implementation mobile robot are measurement a Wi-Fi signal based WPT (Wi-Fi Position Techniques) method with important access points to estimate the position of mobile phone by analyzing the experimental test of in building. Mobile robot is using to get the results of the strength of the signal, besides mobile robot can also be applied for various purposes, such as potential for localization and navigation purposes in areas hard to reach by humans.

II. Research Method

The design and manufacture of tools in this research is divided into two parts, hardware design and software design. The design of the system begins with the design of the overall diagram. From this diagram block, it can be known how the whole system works. Once the breadth of the diagram this diagram will produce a system that can be enabled .

A. Hardware Design

The design of hardware is a tool that will be created begins with the making of the whole diagram. The overall diagram in Figure 1.

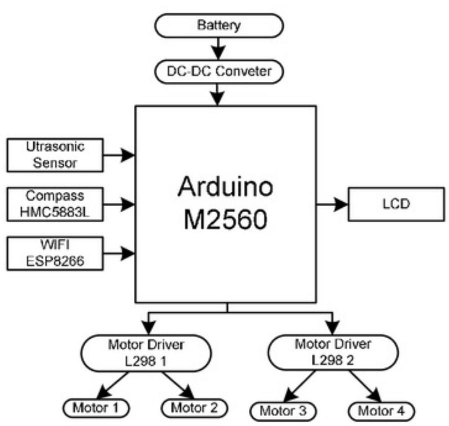

Fig. 1. Diagram Block Hardware

Omni wheel mobile robot positioning system using WI-FI module ESP28266 as a determinant of position coordinates and HMCL5883L compass sensor as a direction determiner. The positioning system also uses the HC-SRO4 Ultrasonic Sensor that is used when the robot goes in the direction and route specified by the operator so this sensor works to measure the distance between the barrier and the sensor (Figure 2).

The ATMega2560 microcontroller is in charge of processing all inputs, running the WPT (Wi-Fi Position Techniques) main function software on this mobile robot, and managing all outputs. In regulating the robot motion as the output action of the mobile robot positioning system, this microcontroller is also used as a regulator of the rotation speed of a permanent magnet DC motor with the main processor acting as a motor driver controller. The motor driver manager functions to adjust the input of the motor driver module, so that the speed and direction of DC motor motion can be adjusted.

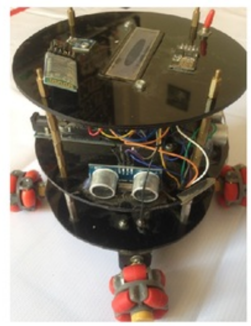

Fig. 2. Mobile Robot Hardware

B. Software Design

WPT (W-Fi Position Techniques) is designed to regulate autonomous mobile robot motion in achieving goal positions. The positioning system is designed to enable the robot to recognize positions and directions based on the Earth's coordinate system, capable of performing correction of the bearing correction and odometer to improve accuracy in reaching the destination position, by route or location specified by the operator. Reach the destination position, with the route or location specified by the operator.

Here are some examples of coding used when testing robots using arduino mega to gain signal strength from each available access point, such as the following:

```
Procedure scan_position
    Send command to esp8266 for scanning access point
    Receive all string from esp8266
    X()<-split string
    While i < 4 do
        If (x(i) is in list){
            Get rssi
            Convert into distance i
            Increase i
        }
    End while
    Predict position(x,y) by using distance i
    Return position
End procedure
```

Fig. 3. Pseudo Code

III. Structure System

To realize the localization of the mobile robot inside the building (indoor), there are preparations that will have been undertaken :

A. Position of the mobile robot between Wi-Fi AP

In principle, at least there are several hotspots needed to reach the position, and the number of hotspots affect position accuracy. For that we will prepare a rectangular area with size 8x3 m with 4 hotspots available.

Fig. 3. The position of the mobile robot between Wi-Fi AP

Based on the position of the robot between the Wi-Fi above, if at the reference point 1 and 5 will produce a very large dBm value because the location is farthest from the robot. At reference point 2 and 3 will produce the same small dBm value because it is near the robot in close proximity. At points 6 and 7 are the same as dBm values at reference points 2 and 3 because the distance between the reference point and the robot is approximately equal.

Furthermore point 8 and 9 will produce dBm values that are 2 times smaller than the reference point 2,3,6, and 7 because the location is almost close to the robot. And at point 4 it produces the smallest dBm value because it is closest to the robot. Thus, the distance between the robot position to the reference point 1 to the other determines the small dBm value according to the proximity of the reference point access point to the robot position.

In the Figure 3 above can also show that in practice, mobile robot can receive multiple hotspot signals inside the building (indoor), for example is on the hotspot signal from the nearest area, from the signal strength of each hotspot, etc. Compared to the positioning area, the position will include a relatively small or narrow area of the square that will cause the signal position will not change. However, such signals will have a positive impact on mobile robots in the indoor area which will greatly help gain significant accuracy on those signals.

B. Signal Strength

Database is the basic information source to get signal strength from each Wi-Fi. The accuracy of the Wi-Fi signal limited by coordinating the larger destination position to determine the position of the mobile robot within the area. After getting the signal strength of each Wi-Fi it will be stored and collected in the database. This depends on the value of the position of each hotspot by doing two ways: the first is by taking the database manually because if not on a small area will not increase the workload that will affect the signal strength of Wi-Fi. Second is to limit the mobile robot coverage area under the control of the robot program.

The database acquisition process does not depend on the number and position of the Wi-Fi and how to adapt it from the mobile robot by the new area. That is when the mobile robot arrives in an unfamiliar area, which provides an area of more than 4 hotspots, the mobile robot will automatically move beyond what we expect and can directly create the database of the Wi-Fi signal's power output. Depends on the number and the position of the Wi-Fi and how to adapt it from the mobile robot by new area. That is when the mobile robot arrives in an unfamiliar area, which provides an area of more than 4 hotspots, the mobile robot will automatically move beyond what we expect and can directly create the database of the Wi-Fi signal's power output.

IV. Results and Discussion

The test is carried out in the indoor area of 8x3 size, as discussed in Part II, and shown in Figure 3. The robot position between the 4 Wi-Fi hotspots is installed in the corners, 9 reference points are specified, as shown in Table I.

TABLE I. POSITION OF DATA FOR DISTANCE POINT

Point	Distance	Signal Strength of Wi-Fi (dBm)			
		AP1	AP2	AP3	AP4
1	30 cm	-20	-45	-50	-62
2	1 m	-34	-47	-53	-64
3	2 m	-38	-51	-57	-69
4	3 m	-43	-53	-63	-72
5	4 m	-47	-49	-66	-64
6	5 m	-53	-51	-53	-59
7	6 m	-40	-53	-48	-51
8	7 m	-38	-47	-43	-48
9	8 m	-48	-51	-56	-63

The table II shown that on each access point available to produce different values. This is because the signal strength of each of the wi-fi can be changed or approximate, as in the 6th row the AP1 signal diminishes as well as AP2-4 will experience a decrease of a signal due to lack of precision in the area.

After performing the measurements at the reference point spacing, then perform the simultaneous in the same way to obtain the result of the strength of the signal by using the exponential equation obtained through the test results, hence the formula may be as follows:

$$Y = 0.0389\, e^{0.089x} \quad (1)$$

The above formula is an exponential equation calculated using Microsoft Excel. With the following information:

Where :
Y = non-free variable (result value from RSSI)
X = free variable (RSSI from wifi)
0.0389 = (constants value)
0.089 = (constants value)

From equation (1) then with manual calculation from test table I got the result of signal strength whose value is listed in Table II.

TABLE II. TESTING DATA FOR EACH AP (ACCESS POINT)

POINT	Distance (m)	Signal Strength of Wi-Fi (dBm) (x)				Result of signal strength by using Exponential (m) (y)			
		AP 1	AP 2	AP 3	AP 4	AP 1	AP 2	AP 3	AP 4
1	0.3	-20	-45	-50	-62	*0.5*	*1.1*	*1.4*	*1.7*
2	1	-34	-47	-53	-64	*3.0*	*4.3*	*2.3*	*8.8*
3	2	-38	-51	-57	-69	*5.6*	*5.6*	*3.6*	*13.*
4	3	-43	-53	-63	-72	*9.6*	*3.6*	*4.7*	*7.4*
5	4	-47	-49	-66	-64	*11*	*5.1*	*8.8*	*10.*
6	5	-53	-51	-53	-59	*7.4*	*7.4*	*13*	*1.6*
7	6	-40	-53	-48	-51	*8.8*	*9.6*	*2.1*	*2.7*
8	7	-38	-47	-43	-48	*6.2*	*5.1*	*5.6*	*6.7*
9	8	-48	-51	-56	-63	*8.1*	*11.*	*10*	*13*

Based on the above table that on AP 1 with reference point 1-9 produce different values, be it small or large value. And so on is found on AP 2 - AP 4 with each reference point being different. The resulting dBm value will experience a decrease due to the signal strength of each Access Point can vary according to the condition of the area such as due to wall / concrete, even antenna position is very influential.

To get a good signal strength results done with the tests performed as in table II above. The table above shows that the closer the reference point distance to the robot position the greater the dBm value and the distance from the signal strength decreases from the reference point. Conversely, if the distance of the reference point to the position of the robot, the smaller the dBm value and the distance from the signal strength increasing from the reference point.

V. CONCLUSION

With the proposed design, a design to determine the position of mobile robot in the form of available access point based on the accuracy of the existing Wi-Fi hotspot signal by using WPT (Wi-Fi Position Techniques). We can accurately estimate the position which the mobile robot is located. The experiment results show that there is still a slight change of value on each measurement result of several reference points caused by several conditions such as on the wall/concrete, antenna position, etc. This often happens and results in the power of the signal is inconstant and inaccurate. However, changes to the test are within a reasonable and acceptable range.

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REFERENCES

[1] C. Rohrig and F. Kunemund, "Estimation of position and orientation of mobile systems in a wireless LAN," *2007 46th IEEE Conf. Decis. Control*, pp. 4932–4937, 2007.

[2] Christopher J. Hegarty, "The Global Positioning System," *Springer Handb. Glob. Navig. Satell. Syst. pp*, p. pp 197–218, 2017.

[3] A. Mulloni, D. Wagner, I. Barakonyi, and D. Schmalstieg, "Indoor positioning and navigation with camera phones," *IEEE Pervasive Comput.*, vol. 8, no. 2, pp. 22–31, 2009.

[4] E. M. Gorostiza, J. L. L. Galilea, F. J. M. Meca, D. S. Monzú, F. E. Zapata, and L. P. Puerto, "Infrared sensor system for mobile-robot positioning in intelligent spaces," *Sensors*, vol. 11, no. 5, pp. 5416–5438, 2011.

[5] J. D. Domingo, C. Cerrada, E. Valero, and J. A. Cerrada, "Indoor Positioning System Using Depth Maps and Wireless Networks," *J. Sensors*, vol. 2016, 2016.

[6] H. Liu, H. Darabi, P. Banerjee, and J. Liu, "Survey of Wireless Indoor Positioning Techniques ans Systems," *{IEEE} Trans. Syst. Man Cybern. C Appl. Rev.*, vol. 37, no. 6, pp. 1067–1080, 2007.

[7] L. M. Ni, Y. Liu, Y. C. L. Lau, and A. P. Patil, "LANDMARC: Indoor Location Sensing Using Active RFID," *Wirel. Networks*, vol. 10, pp. 701–710, 2004.

[8] J. J. Caffery and G. L. St??ber, "Overview of radiolocation in CDMA cellular systems," *IEEE Commun. Mag.*, vol. 36, no. 4, pp. 38–45, 1998.

[9] R. J. Fontana, "Recent system applications of short-pulse ultra-wideband (UWB) technology," *IEEE Trans. Microw. Theory Tech.*, vol. 52, no. 9 I, pp. 2087–2104, 2004.

[10] M. J. Segura, V. A. Mut, and H. D. Patiño, "Mobile robot self-localization system using iruwb sensor in indoor environments," *2009 IEEE Int. Work. Robot. Sensors Environ. ROSE 2009 - Proc.*, no. August 2016, pp. 29–34, 2009.

[11] B. Li, J. Salter, A. Dempster, and C. Rizos, "Indoor positioning techniques based on wireless LAN," *Conf. Wirel.*, pp. 13–16, 2006.

[12] A. H. Ismail, H. Kitagawa, R. Tasaki, and K. Terashima, "WiFi RSS fingerprint database construction for mobile robot indoor positioning system," *2016 IEEE Int. Conf. Syst. Man, Cybern. SMC 2016 - Conf. Proc.*, pp. 1561–1566, 2017.

[13] P. Jiang, Y. Zhang, W. Fu, H. Liu, and X. Su, "Indoor mobile localization based on Wi-Fi fingerprint's important access point," *Int. J. Distrib. Sens. Networks*, vol. 2015, 2015.

[14] G. S. Tewolde and J. Kwon, "Efficient WiFi-Based Indoor Localization Using Particle Swarm Optimization," pp. 203–211, 2011.

[15] K. Wu, J. Xiao, Y. Yi, D. Chen, X. Luo, and L. M. Ni, "CSI-Based Indoor Localization," *IEEE Trans. Parallel Distrib. Syst.*, vol. 24, no. 7, pp. 1300–1309, 2013.

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