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Indoors localization system with the use of WiFi and other network standards

Abstract. *In this paper there is information about the methods of determining the localization inside the buildings and a description of the experiment program to measuring the distance from the AP.*

Streszczenie. *Artykuł opisuje metody lokalizacji wewnątrz budynków za pomocą˛ standardów sieciowych. Opisany został też˙ eksperyment polegający na określaniu położenia użytkownik względem punktu access point (AP).* ***(Lokalizacja wewnątrz budynków przy użyciu WiFi oraz innych standardów sieciowych)***

Keywords: WiFi, GPS, indoor positioning system
Słowa kluczowe: WiFi, GPS, lokalizacja wewnątrz budynków

Introduction

People localization inside buildings using satellite systems such as GPS or Glonass gives an inefficient accuracy by the lack of direct "visibility" satellites placed on the orbit. This situation occurs while entering into the tunnel, between the tall buildings or high forest as well inside the building. In that case the GPS signal is lost, reflected or distorted. People spend more than 80% of their time inside buildings [source??]. Current mass available solutions can determinate the accurate localization only outdoors. This paper presents alternative ways how to solve the situation of unavailability of localization by GPS inside large buildings. The paper presents the results of determining the position of the mobile device relative to the access point (AP). The walls and ceilings cause the lack of classical GPS signal inside the buildings. Similarly, frames of reinforced concrete structures in tunnels, underground garages and metro create impenetrable or highly suppressed structure for GPS signal by Faraday's cage. The natural way to deal with lack of access to the GPS signal is the use of repeaters installed inside buildings. With this solution it is possible to use existing receivers for which mounted amplifiers are transparent so that no change is needed or software configuration and the transition is smooth between the amplifier and the satellite. Existing solutions due to their technology can be used only in a narrow application.

Localization by iBeacon

Commercial solution that uses indoor localization method is iBeacon by Apple based on Bluetooth LE (Bluetooth Low Energy). The assumption is to built a system of reception (iBeacons) mounted in determinate locations within the building. The second element of the system is a mobile device (e.g. iPhone) with installed appropriate iBeacon program that detects and displays location data of each Beacon. The technology and appliance of iBeacon system is easy, however localization by this method requires an usage of large number iBeacon devices. Thus the proper location may not be available in all areas.

An extension of the above method is the ability to determine the accurate location based on signal strength received simultaneously from multiple devices (iBeacons). Then, after applying a calculation by triangulation to determine the location of man as well a distance from the know position of the AP with high accuracy.

Other methods of localization indoors

Alternative method of man localization is combining method of compilation an accelerometer and a gyroscope already built-in mobile phone. By the cross checking information received from both devices and determined localization by GPS signal it possible to recreate the moving path of traced person and allows to find his current position.

Fig 1. iBeacon with Bluetooth low energy module

Limitations of localization methods

The unlimited localization of persons inside the buildings has take the risks. The main is the limited confidence of traced and controlled persons to the current available systems of localization. One of the actual available methods to prevent identification is a special application developed by Apple. This program is based on a pseudo-random address amended on the network card before logging in to a Wi-Fi network. This method seems to exclude unauthorized localization and tracking systems. However the same manufacturer (Apple Inc.) offers the anti anti tracking and localization application that is able to predict the next pseudo-random address.

Currently available commercial systems use Wi-Fi network to determine person's location, however, the accuracy and popularity due to the specialized equipment is limited. IndoorAtlas system uses signal strength triangulation to determine the position of the tracing person at the nearest transmitter to the area in which the thus person is located. (In-DoorAtlas, 2014) The other presented systems show different methods of the indoor localization. Systems based on the GPS receiver's modification require huge power antennas thus their usefulness is significantly limited. Localization systems based on wireless signal require a permanent connection to the network. Finally systems employing gyroscope and accelerometer allow determining the current position with a small accuracy. In a conclusion the appropriate development of the hybrid system that will employ all above presented systems should give the highest accuracy in localization using the most economical efficiency.

Description of the method of determining the localization

The experiment relied to create a connection between the access point (AP) and the device with built-in network that supports Wi-Fi. In this case, testing was conducted in two smartphones. One has been applied as AP (transmitter) and the other (smartphone Samsung GT-S7580 equipped with the appropriate software) has been applied to determine the distance (receiver). It has been placed in a known distance from the access point inside the building

Fig 2. Screen of the program on the phone designating the distance to the AP

$$P = 20\log_{10}(d) + 20\log_{10}(f) - 27.55$$

$$-20\log_{10}(f) + P + 27.55 = 20\log_{10}(d)$$

$$\frac{1}{20}\left(-20\log_{10}(f) + P + 27.55\right) = \frac{20\log_{10}(d)}{20}$$

$$\log_{10}(d) = \frac{1}{20}\left(-20\log_{10}(f) + P + 27.55\right)$$

$$d = 10^{\left(\frac{1}{20}\left(-20\log_{10}(f)+P+27.55\right)\right)}$$

$$d = \frac{10^{\frac{P}{20}+\frac{551}{400}}}{f}; \quad d = \frac{10^{\frac{20P+551}{400}}}{f}$$

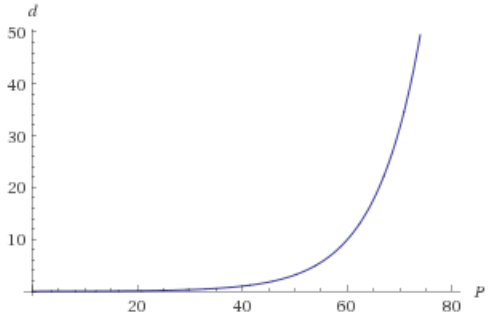

Fig. 3. Dependence between the power P and the distance signal which is received

The installed software has been written to calculate the distance from access point, based on the signal strength that determines the distance from the access point (AP).

Experimental measurements of a distance was carried out on 3 levels 0.0 m, 0.5 m and 1.5 m height relative to the position of the access point (AP). The measurements were performed inside the building at a distance from AP 0 to 10 m at intervals of 0.5 m.

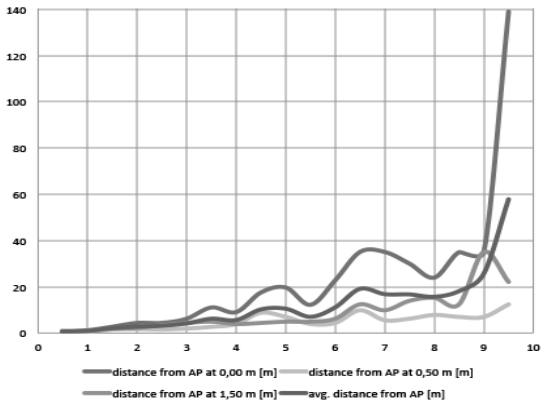

Fig. 4. Accuracy depending on the height at which the measurement was conducted

Conclusions

Analyzing the measurements obtained from the program can be determined that the best results are achieved at the height level of 0.5 m. The best result close to the real measurements contains in the range from 0 to 4 m. The biggest deviation from reality contains in the range of 9 m to 10 m. Such results follow from the way of radio waves propagation.

By this experiment one determines the approximate accuracy of the user's position within 5 m from the device. To increase the accuracy of determining the localization should increase the power of the device and increase the count to minimum 3 AP to use triangulation method determining the localization of the signal in a 3-dimensional space

REFERENCES

1 Chen, Y., & Kobayashi, H.: Signal Strength Based Indoor Geolocalisation, Department of Electrical Engineering School of Engineering and Applied Science Princeton University, 2002.

2 Chin-Heng Lim, Y. W.-P.: A Real-Time Indoor WiFi Localization System Utilizing Smart Antennas, NTU, Singapore

3 InDoorAtlas: InDoorAtlas, [web page] https://www.indooratlas.com/, Sep 2014. [Accessed on 20 Sep. 2014.].

4 Nirjon, S., Liu, J., DeJean, G., Priyantha, B., Jin, Y., & Hart, T.: COIN-GPS: Indoor Localization from Direct GPS Receiving. A Real-Time Indoor WiFi Localization System Utilizing Smart Antennas, University of Virginia Microsoft Research, Redmond, WA.,2014.

5 Pietrusiewicz, W.: iMagazine, [web page] http://imagazine.pl/2014/07/03/exclusive-apple-udzieli-licencji- Sep 2014. [Accessed on 7 Sep. 2014.].

6 Qifan Pu, S. G.: Whole-Home Gesture Recognition Using-Wireless Signals, University of Washington, 2013.

7 Tran, K., Phung, D., Adams, B., & Venkatesh, S.: Indoor localization Prediction Using Multiple Wireless Received Signal Strengths University of Washington, 2012.

8 Yapeng Wang, Xu Yang, Yutian Zhao, & Yue Liu, Laurie Cuthbert.: Bluetooth Positioning using RSSI and Triangulation Methods. Beijing University of Posts and Telecommunications, Macao Polytechnic Institute, University of London, 2013.

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