

doi:10.15199/48.2016.12.48

Probabilistic methods for determining position using WiFi signal

Streszczenie. W artykule przedstawiono probabilistyczne metody określania położenia za pomocą sygnału WiFi przy wykorzystaniu klasycznego telefonu komórkowego z wbudowanym modułem WiFi.

Abstract. In this article we present probabilistic methods to determine the position using the WiFi signal with the use of a classic mobile phone with built-in WiFi. (**Probabilistyczne metody określania położenia za pomocą sygnału WiFi**).

Słowa kluczowe: lokalizacja, wifi, gps, metody probabilistyczne

Keywords: localisation, wifi, gps, probabilistic methods

Introduction

Localizing WiFi signal has become extremely popular over the recent years. The most common method is the use of so-called fingerprinting. To 'fingerprint' means to correlate a signal's strength (RSSI) of the actual position by an observation on the map. This technique is widely used in scientific researches of building a system of object identification. The studies present data analysis carried throughout a survey of fingerprinting the map, defining quality parameters of the signal.

To achieve the goal of creating data for analysis, two identical access points emitting a WiFi signal need to be arranged at a predetermined distance. Secondly, the data to create fingerprints is to be taken using a mobile phone equipped with a network card and an application, created for this purpose, collecting data about a signal emitted by the access points. Data collected during the first measurement is used to create the first map of fingerprints. They are identified as so-called reference data owing to which studies are next to be conducted. Subsequent measurements are carried out using the same methods, while data are stored in the database of the fingerprints.

This database is used as the basis for data analysis, during which data is compared with the reference ones and measurements are studied. Data is compiled by calculating the median, mode, arithmetic mean and the minimum and maximum value. The obtained values are then used to compare the value of statistical functions with the values of the data collected. The collected data is compared with the determination of likelihood of the value of a statistical function in the tested values of measurements of signal strength.

Related work

The location inside the building is used to facilitate navigating in the vast office complexes, shopping malls and airports. Location identification gives the opportunity to lead the most optimal route to one's target reach. In the present studies, using a variety of techniques for determining the position of: Time of Arrival, Time of Arrival-Difference, Direction of Arrival, and feed means received signal strength [1]. Location methods can be divided into two categories: first based on fingerprints and second one based on mathematical models [2]. Fingerprints method is used to build maps correlated with each of the individual values of measurements of the RSSI signal at a given location. To create such fingerprinted maps different technologies are being used, such as: FM radio, DVB-T, Bluetooth LE and WiFi [3]. Methods based on Wi-Fi and Bluetooth require large quantities of transmitters as compared with solutions based on FM or DVB-T. The use of the first two solutions makes it possible to determine the

position with much greater accuracy. The use of Bluetooth solutions require the placement of a much larger volumes of transmitters than the WiFi one. The use of WiFi makes it possible due to infrastructure and also assured communications and Internet access in the building [5].

Problems in indoor navigation

The biggest problem in the navigation inside the building is the GPS impossibility of action. This is due to attenuation of the GPS signal by building structures. The GPS signal inside a building can be very weak and the building attenuation can be up to 30 dB [6]. Such high damping reduces the quality of the received signal and how it is related to the accuracy of determining the position. Wireless systems based on GPS as opposed to inside the building possibility to obtain less attenuation due to the characteristics of the construction involving the multiplication of transmitting points. The use of a system based on WiFi gives the ability to use the existing infrastructure within the building to share the Internet.

Experiment description

The experiment was to create a map of fingerprints in a room. To build the measurement system two identical APs wireless WiFi with external antenna were used. Access points were placed in two unchanging locations spaced about 25 m from each other [9]. The configuration of devices applied blocking the transmitting power to a fixed value and setting channels so that they can collide. The first AP (AP1) was configured to broadcast on a channel 1 at the frequency of 2,412 MHz and a second Access point (AP2) was set up on a channel 6 at the frequency of 2437 MHz [4]. Access Points used in the measurements: ASUS RT-N10U with external antenna with 5 dBi gain. Both the router are set opposite each polarization antennas was both routers the same. Antennas of routers were directed against each other.

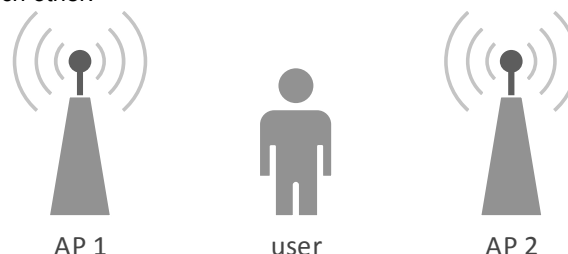


Fig. 1. – Fig. of measurements lab

To collect data on the power of the signal emitted by AP1 and AP2 a mobile phone with built Wi-Fi receiver was used. The phone was equipped with a specially created

application for creating fingerprinted maps. The application collected data such as manual selecting (physical distance from the access point) in its memory. The measurements were carried out using the phone Samsung Galaxy Trend Plus S7580.

Analysis of collected data

Data collected during the experiment were analyzed. The data were collected in a form of a vector containing the physical distance between the router and the signal's strength [Table 1]. On the basis of signal strength measurements for each point away from the access point. Calculated probability showed that the measurement corresponded to the actual power of the signal received at a given point. The probability was calculated as the ratio of the measurements corresponding to the measurement reference to the number of all the measurements at that point. The average probability for each of the statistical functions was provided in Table 2. From these calculations can be seen that mode as a function of statistical best describes the reality of [Fig. 3].

Table 1. – The example of data vector

distance [m]	RSSI [dBm]
1	2341

Table 2. – The probability of statistic functions

function name	avg probability
max	0,3173
min	0,3221
mode	0,4375
median	0,3462
avg	0,1058

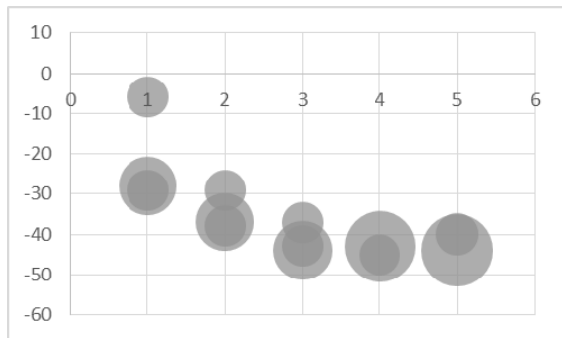


Fig. 1. - measurement of the probability distribution for the individual measuring points in the system for a distance of less than 5m

Using the formula:

$$P(A) = \frac{s}{m}$$

P(A) the probability that a given value of the statistical function is equal to the reference measurement for each . s – the number of samples complying, m - the total number of measurements.

$$avg P(A) = \sum_{i=1}^{25} \frac{P(A)}{25}$$

avg P(A) the average probability of matching for each of the studied statistical functions

Using the probability can also determine the probability with which a given point determines the correct position for this purpose were calculated probability P (B).

$$P(B) = 1 - \frac{s}{n}$$

s – the number of samples complying, n - the total number of measurements.

$$P(I|o) = \frac{p(o|I)p(I)}{p(o)} = \frac{p(o|I)p(I)}{\sum_{I'} p(o|I')p(I')}$$

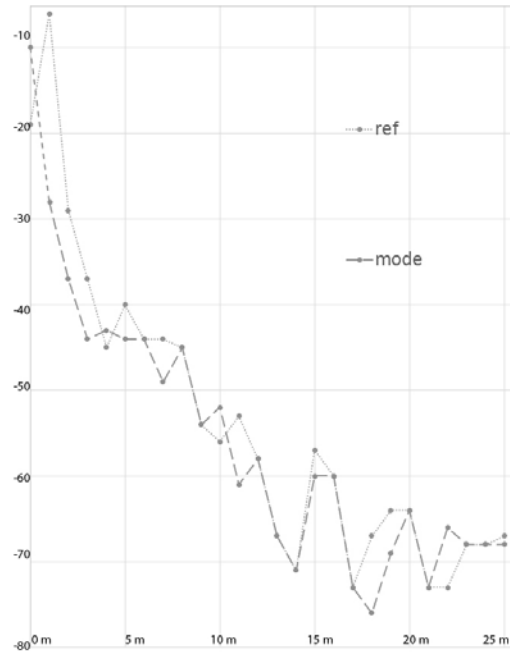


Fig. 2. – comparison of reference and function mode

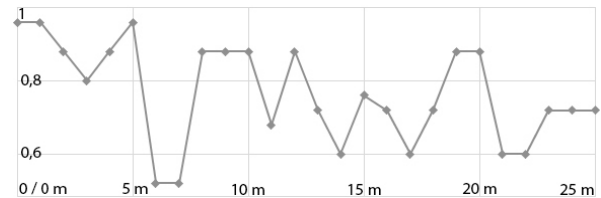


Fig. 3. – the probability of a correct position depending on the distance

where I denotes location, o denotes an observation variable or vector, p(I | o) is the posterior probability of being at location I after getting the observation variable o, and p(I) is the prior probability of being at location I before knowing the value of the observation variable.[8]

$$p(o|I) = \prod_i p_{i,I} \cdot k_i(o_i = \overline{RSSI_{k_i}}|I)$$

where is the probability of receiving the strength of RSSI from the AP i when being at the position I, and the integral interval is, the range of signal strength is limited to the negative integer [8].

The measurement of mean square error

In a further step of data analysis for all math functions example: max, min, mode, media . It has been calculated mean square error.

Table 3. – The MSE of statistic functions

function	Mean Squared Error [RSSI]
media	2,51
prob avg	2,93
avg	2,97
gauss filter	3,26
min	3,52
mode	4,21
triangle filter	4,24
max	4,26
max value	4,34

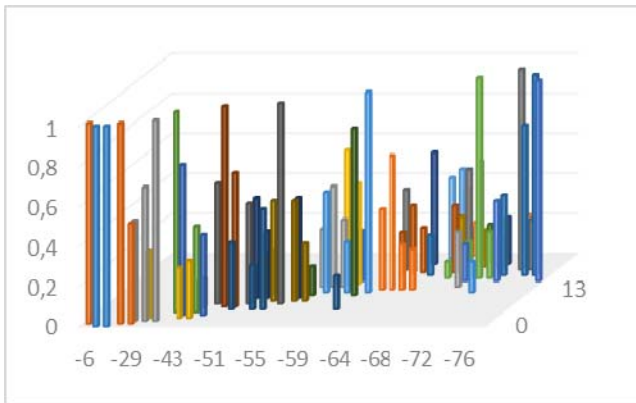


Fig. 4. – measurement of the probability distribution for the individual measuring points in the system

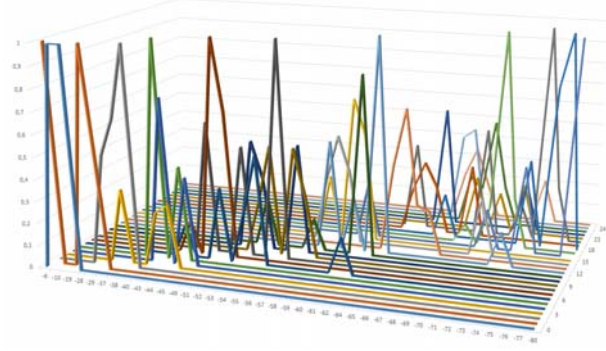


Fig. 5. – measurement of the probability distribution for the individual measuring points in the system

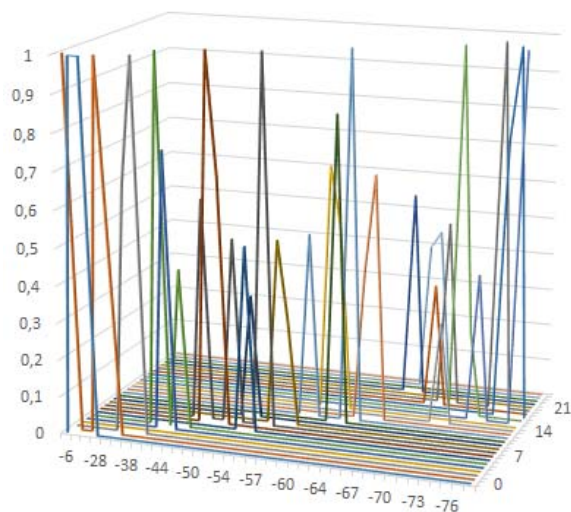


Fig. 6. – Gaussian filter adaption on probability distribution for the individual measuring points

On the collected data were carried filtration and gaussian filter is applied triangular through the use of these two can be filtered to extract a better set of data . The collected data show the smallest MSE is a function median

Conclusion

Using the experiment described above, by imposing fashion feature on the collected data at a given point, one can determine the statistically most probable signal's strength. Thus, data can be collected using a map-based

fingerprints which determine the relative position of the access point. With the data collected can be in a statistical way to determine which statistical functions best describes reality and is closest to the reference measurement. We can also determine the probability of the accuracy of a measurement at a given location.

Future work

To develop this research one can increase the number of access points and add information from receivers IBeacon if they exist in the environment. They are promising hopes for a solution based on a use of intensified data with a use the electromagnetic field or the compass [7]. The next stage of the work will be to build a robot measuring equipped with Bluetooth receivers accelerometer compass magnetometer and other sensor through which it will be possible to create.

Authors: DSc Piotr Lipiński Institute of Information Technology, Lodz University of Technology, ul. Wólczańska 215, 90-924 Lodz, Poland, email: piotr.lipinski@p.lodz.pl M. Sc. Marcin Leplawy Institute of Information Technology, Lodz University of Technology, ul. Wólczańska 215, 90-924 Lodz, Poland, email: marcin.leplawy@dokt.p.lodz.pl, PhD,

REFERENCES

- [1] WicLoc: An indoor localization system based on WiFi fingerprints and crowdsourcing, Jianwei Niu, State Key Lab. of Virtual Reality Technol. & Syst., Beihang Univ., Beijing, China, Bowei Wang, Long Cheng, Joel J. P. C. Rodrigues, 2015 IEEE International Conference on Communications (ICC), Pages: 3008 – 3013, 2015
- [2] WILL: Wireless Indoor Localization without Site Survey, Chenshu Wu, Tsinghua University, Beijing, Zheng Yang, Yunhao Liu, Wei Xi, IEEE Transactions on Parallel and Distributed Systems (Volume: 24 , Issue: 4), Pages: 839 - 848, 2015
- [3] Gradient-Based Fingerprinting for Indoor Localization and Tracking, Yuanchao Shu State Key Laboratory of Industrial Control Technology, Zhejiang University, Hangzhou, China, Yinghua Huang, Jiaqi Zhang, Philippe Coué, Peng Cheng, Jiming Chen, Kang G. Shin, IEEE Transactions on Industrial Electronics (Volume:63 , Issue: 4), Page: 2424 – 2433, 2016
- [4] IEEE-SA -IEEE Get 802 Program - 802.11: Wireless LANs[web page] <http://standards.ieee.org/about/get/802/802.11.html> Apr 2016. [Accessed on 8 Apr. 2016.].
- [5] RSSI-Based Bluetooth Indoor Localization, Yixin Wang, Dept. of Comput. Sci., Univ. of Prince Edward Island, Charlottetown, PE, Canada, Qiang Ye, Jie Cheng, Lei Wang, 2015 11th International Conference on Mobile Ad-hoc and Sensor Networks (MSN), Pages: 165 - 171, 2015
- [6] Ray tracing supported precision evaluation for GPS indoor positioning, M. Jacob; S. Schon; U. Weinbach; T. Kurner, Positioning, Navigation and Communication, 2009. WPNC 2009. 6th Workshop, Pages: 15-22, 2009
- [7] An Android-based Mechanism for Energy Efficient Localization depending on Indoor / Outdoor Context, Nicholas Capurso; Tianyi Song; Wei Cheng; Jiguo Yu; Xiuzhen Cheng, IEEE Internet of Things Journal, Page: 1, 2016
- [8] On Hybrid Localization in Half-Open Areas , Geng Li ; Sch. Of Electron. Eng. & Comput. Sci., Peking Univ., Beijing, China ; Kaigui Bian ; Yuping Zhao ; Dou Li, 2015 IEEE 81st Vehicular Technology Conference (VTC Spring), 2015
- [9] Particle filter robot localisation through robust fusion of laser, WiFi, compass, and a network of external cameras.Canedo-Rodriguez, Alvarez-Santos, Regueiro, C., Iglesias, R.,Barro, S.a, Presedo, J. University of Santiago de Compostela, University of A Coruna, 2016