Universe Scientific Publishing

Ubiquitous Intelligent Floor Combined Positioning Method Based on Fusion of Bluetooth Signal and Barometer

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Abstract: Of the indoor floor location and complex environment, this paper, we research the Bluetooth signal attenuation of signal in multi-storey buildings, was proposed based on the Bluetooth signal and the barometer of fusion in intelligent floor combination positioning method, according to the structure of the building and receive the number of AP switch under different indoor environment using the matching algorithm, to adapt to a wider range and higher accuracy. In the case of less AP, the experimental results show that the static floor positioning accuracy reaches 95% in different building environments.
Keywords: Floor Positioning; Signal Attenuation; Bluetooth; Air Pressure

Introduction

In recent years, with the rapid development of mobile computing and other technologies, location-based services (LBS) have become more and more important both in the field of science and technology in daily life. In the outdoor, people mainly rely on global Positioning System (GPS), Beidou Navigation Satellite System (BDS) and other satellite positioning technology to obtain reliable and real-time location information. However, in the indoor area where people spend most of their time, satellite positioning technology cannot play an effective role due to the occlusion of buildings, so it is necessary to rely on indoor positioning technology to meet people's needs for indoor positioning[1].In recent years, there have been many indoor positioning methods based on infrared, radio frequency identification (RFID), Bluetooth, wireless LAN, UWB, computer vision, geomagnetic and other technologies. However, most of these positioning algorithms focus on two-dimensional plane positioning, and relatively little attention is paid to three-dimensional floor recognition [2-5].

At present, there are two main floor location methods, one is floor location method based on wireless signals, such as Deng [6] Et al. introduced a floor determination method of wireless LAN based on K-means clustering. However, in the multi-level space with atrium structure, especially in the large-scale multi-storey indoor space, the RSSI changes of the same AP on different floors are not obvious, and the signal similarity is very high. The literature [7] The sum-RSSI floor algorithm is mainly introduced. This method does not need to establish a fingerprint database in advance, and uses RSSI to determine floors from real-time collection. RSSI outliers are removed first, and then RSSI average values of all APS are aggregated, and finally the floor corresponding to the maximum aggregate average RSSI value of AP group is determined as the target floor. Another is floor location based on air pressure, e.g. Muralidharan et al. [8] It was observed that although the absolute pressure of each floor varied greatly over time, the difference in pressure between floor pairs remained stable. They get horizontal heights relative to floors by detecting the number of floors using pressure differences, rather than the actual floors, which has some limitations.

1. Signal attenuation of Bluetooth signal in multi-storey buildings

This article takes into account the bluetooth signal under the condition of two different indoor signal attenuation, and according to the signal attenuation pattern of multiple floors building leads to the same AP receiving probability in different floors and received signal strength is different of the properties, using the appropriate localization algorithm in different situations, so as to realize high accuracy, coverage of the floor more recognition.

1.1 Signal attenuation of Bluetooth between different floors

To test the bluetooth signal attenuation caused by floor block value, in jiangxi normal university Su first floor test field collected some fixed AP current floor and adjacent signal strength value of the floor, the floor where the bluetooth right in front of the AP and the base station is located in the adjacent floors of patch is below the current floor vertical projection, sampling time is 30 s, the sampling frequency of 1 hz. According to the experiment, the Bluetooth signal can only be transmitted to adjacent floors. For example, on the 6th floor, the bluetooth signal can only be received from the current floor and adjacent floors, but not from two adjacent floors.

1.2 Signal attenuation of Bluetooth on the same floor

It is known that the propagation distance of wireless signal is different under different propagation path loss models. Although each signal node transmission power is the same, but in the actual environment, the spread of diffraction, reflection, multipath and obstacles such as the existence of the unstable factors on the transmission of wireless signals weaken the role of the attenuation factor is also changing along with the changes in the environment, so we should according to the different environment to choose different channel model is set up according to the parameters. There are some commonly used propagation models, such as free space propagation model, logarithmic distance loss model and logarithmic normal model[10].The free space propagation model is very simple. It is built under ideal conditions, and the loss of the signal is only related to the propagation distance and frequency of the signal.

2. Floor positioning method of this paper

Aiming at the limitation of the WIFI signal in the hollow area and use the barometer the lack of stability, this paper proposes a fusion based on bluetooth signal and barometer of the pan in the smart floors combination positioning method, the method considering all the different structure buildings, in the ordinary multi-layer environment using floor recognition method based on improved K neighbor algorithm, The floor location method based on fuzzy membership degree is used in hollow environment, and the floor location method based on air pressure is used in the environment with weak Bluetooth signal, such as elevator.

2.1 Algorithm flow

In the offline phase, the fingerprint database can be established by counting the Mac addresses of deployed aps on each floor, matching the Mac addresses of deployed aps on each floor, and collecting the RSSI values of different aps at different collection points. During the online phase, Mac addresses of all aps detected within 1s are displayed

As the input, the best matching algorithm is judged according to the signal strength and the number of aps collected.

2.2 Floor location algorithm of fuzzy membership degree

This method theoretically assigns a membership degree to each object for each cluster, and the value range of membership degree is [0,1], indicating the degree to which each object belongs to the cluster. This method is more consistent with the actual floor positioning, which can not only meet the needs of floor positioning in most regions, but also improve the positioning accuracy of special regions. In the method in this paper, the RSSI value interval of each Bluetooth AP on each floor is set as different clusters, and the midpoint of the RSSI value interval is used as the center of each floor cluster to calculate the membership degree, as follows:

In floor division, the offline RSSI value interval library of each floor is established. They are collected around AP on each floor of the building and stored in the interval database with the current floor number. The pattern is as follows:

$$\begin{matrix}\{\{F_1,(AP_1,RSSI_{min},RSSI_{max}),\cdots\cdots(AP_j,RSSI_{min},RSSI_{max})\},\cdots\cdots \\ \{F_n,(AP_1,RSSI_{min},RSSI_{max}),\cdots\cdots(AP_j,RSSI_{min},RSSI_{max})\}\}\end{matrix} \quad (4\text{-}1)$$

In the formula, is the floor number, respectively the MAC address of the bluetooth AP that can be received by the

current floor and the minimum and maximum RSSI values of each AP on the floor, namely, the RANGE of RSSI values. $Fi, i \in [1, n]$ $AP_j, RSSI_{min}, RSSI_{max}, j \in [1, m]$

During positioning, the membership degree of each currently received AP to each floor is calculated respectively. The RSSI value of an AP that can be received by mobile phone and the Euclide distance of the AP in the center of each floor cluster are calculated, that is:

$$RSSI_{ic} = \frac{RSSI_{max} + RSSI_{min}}{2} \tag{4-2}$$

$$E_{apj} = \sqrt{(RSSI - RSSI_{ic})^2}, i \in [1, n] \tag{4-3}$$

In the formula, is the RSSI value of an AP received, and is the midpoint of the AP in the first-layer cluster. $RSSI$ $RSSI_{ic}$ i Then for an AP that can be received, the membership degree of each floor is calculated respectively, that is:

$$U_{fj} = 1 - \frac{E_{apj}}{\sum_{i=1}^{n} E_{api}}, j \in [1, n] \tag{4 - (4)}$$

In formula (4-4), is the total number of floors, is the European distance between the RSSI value received by an AP and the center of the first-floor cluster, and is the membership degree of an AP to the first-floor cluster. n E_{apj} j U_{fj} j In the stage of floor positioning and discrimination, the membership degree of each floor is calculated for each received AP. Finally, according to the calculation results of each AP, the membership degree of each floor is summed up, and the floor with the highest membership degree is the floor where the current user resides.

3. Scheme design and analysis

Experiment location: In the stairwell on the 5th, 6th and 7th floor of xianyang Building of Jiangxi Normal University, in the normal floor environment on the 7th floor, in the stairwell and elevator, Bluetooth AP was evenly distributed on the wall of the experiment area. The experimental equipment includes smart phones: Huawei Mate10pro, Bluetooth AP: IBeacon-AC model, working environment is 200-240V AC 50/60Hz, transmission frequency is 10 packets/SEC, transmission power is +0dBm(1mW), and protocol is Bluetooth 4.0.

There are 10 Bluetooth base stations in total, with three bluetooth stations on the 5th and 6th floor and four on the 7th floor. The fingerprint database is established by 5 collection points on each floor, and 30 seconds are collected from each point.

Table 3-1 Floor location accuracy

	The elevator	The corridor	The stairs
Traditional floor location method	88%	92%	88%
In this paper, methods	95%	96%	96%

In the experiment, this paper tests the floor location methods of Bluetooth, air pressure and barometric Bluetooth fusion respectively. The combined floor location method of barometric Bluetooth fusion uses Bluetooth to locate the floor, upload the air pressure data, build the floor pressure model, and automatically switch the floor location mode according to the current user's environment. In 90% of cases, the right method can be used to determine the floor and achieve better positioning effect.

References

[1] Chen Ruizhi, Chen Liang. Acta geodaetica et cartographica sinica, 2017, 46 (10): 1316-1326.

[2] T. Moder, P. Hafner, K. Wisiol and M. Wieser. 3D indoor positioning with pedestrian dead reckoning and activity recognition based on Bayes filtering//2014 International Conference on Indoor Positioning and Indoor Navigation. Busan, South Korea: IEEE, 2015: 717-720.

[3] Davidson P, Collin J, Takala J. Application of particle filters for indoor positioning using floor plans[C]// 2010 Ubiquitous Positioning Indoor Navigation and Location Based Service. IEEE, 2010: 1-4.

[4] Abd Rahman M A, Dashti M, Zhang J. Floor determination for positioning in multi-story building[C]//2014 IEEE Wireless Communications and Networking Conference (WCNC). IEEE, 2014: 2540-2545.

[5] Li Y, Gao Z, He Z, Zhang P, Chen R, El-sheimy N (2018) Robust floor localization for multi-sensor localization. IEEE Access 6:76689 – 76699.

[6] Deng Zhongliang, WANG Wenjie, XU Lianming. A Novel Method for Floor Discrimination of WLAN Indoor Location based on K-means Algorithm [J]. Software, 2012, 33 (12): 114-117.

[7] Maneerat K, Prommak C (2014) An Enhanced floor estimation algorithm for indoor wireless localization systems using confidence Int J Comput, Electr, Autom, Control Inf Eng 8(7):1182 – 1186.

[8] Muralidharan, K.; Khan, A.J.; Misra, A.; Balan, R.K. Barometric phone sensors: More hype than hope! In Proceedings of the 15th Workshop on Mobile Computing Systems and Applications, Santa Barbara, CA, USA, 26-27 February 2014; Pp. 1-6.

[9] Wu Qixuan. Research on Low Power Bluetooth 4.0 Indoor Positioning Technology Based on RSSI [D]. Zhejiang University,2018.