Research on a Bluetooth Low Energy Warning Method

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Abstract. With the development of society, intelligent terminal equipment is used more and more widely. The use of intelligent terminals to locate children’s position, to ensure that children are in a safe and controllable range, is more favored by parents. But now the smart watch needs to install the mobile phone card, which depends on the mobile phone traffic to locate, and the cost is relatively high. This paper proposes a Bluetooth low energy warning method to solve this problem. The distance between the two devices is calculated by the signal strength indication value received by the intelligent terminal, and then compare the preset received signal strength indication value with the received signal strength indication value, as well as the preset distance value and the calculated distance value of the two devices. When the received signal strength indication value is less than the preset value or the distance between the devices exceeds any of the preset values, the wireless device and the intelligent terminal will send an alarm at the same time to remind the two sides wearing the intelligent terminal and the Bluetooth device that the distance between the two sides has exceeded the safety value. The Bluetooth low energy warning method proposed in this paper has the characteristics of low cost and low energy consumption.

1. Introduction

With the progress of science and technology, wireless communication has become an indispensable part of people’s daily life. Intelligent terminal devices with wireless communication function are used more and more widely\textsuperscript{[1, 2]}. At present, many wireless communication technologies have been successfully applied to various products and achieved good results, such as micro power wireless technology, Bluetooth technology and so on\textsuperscript{[3]}. The wireless technology of this paper uses Bluetooth communication.

Bluetooth is one of the most widely used short-range wireless communication technologies in the world\textsuperscript{[4]}, with the characteristics of convenient, fast, flexible and safe, low cost and low power consumption, which is widely used in wearable devices and smart home devices\textsuperscript{[5]}. With the emergence of Bluetooth technology, more and more Bluetooth bracelets have entered the market. Bluetooth has the characteristics of low power consumption and low cost. The device equipped with this function can use a button size battery life as long as 10 years. The emergence of smart bracelets\textsuperscript{[6, 7]} has brought convenience to more parents on children’s safety issues.
However, in daily life, many children are under the care of grandparents who are older. Children are full of energy and run around. It is difficult for grandparents to keep up with them. Children’s safety problem becomes an important thing that troubles parents. Therefore, it is more necessary to bring a positioning device to children to make them in a safe and controllable range. But now the smart watch needs to install the mobile phone card, which depends on the mobile phone traffic to locate, and the cost is relatively high. Some existing Bluetooth bracelets have positioning function, but the existing Bluetooth positioning method is to send the Bluetooth signal strength until there is no Bluetooth signal received by the Bluetooth device, and then get the device location information according to the received multiple location information [8]. However, this method cannot prevent the disconnection of equipment in advance, and does not consider that the location of equipment will change and be uncontrollable after disconnection. Therefore, according to the needs of the current society, this paper proposes a new Bluetooth low energy warning method, which uses the smart terminal, i.e. the mobile phone, to receive the received signal strength from the Bluetooth device Indication, calculate the distance between RSSI and Bluetooth device. Once RSSI is less than the preset value or exceeds the preset safe distance value, the Bluetooth device and intelligent terminal can give a warning, warning children and the elderly to pay attention, and ensure the safety of children.

This paper is organised as follows: a Bluetooth warning method is designed based on the RSSI value of Bluetooth device and the distance value calculated by formula, which are presented in Section 2. Section 3 presents a low-power Bluetooth warning method. Section 4 describes working steps and advantages of Bluetooth warning method. Moreover, some conclusions are discussed in Section 5.

2. Distance Calculation Method Based on RSSI
In Bluetooth location technology, the most commonly used method is based on the signal strength RSSI value. RSSI positioning technology includes ranging and non ranging methods [9]. The ranging algorithm is simple and the workload is small, so this paper chooses the ranging method. The essence of the ranging method is to calculate the distance between two devices from the RSSI value of signal strength by calculating the relationship between signal strength and distance in the current environment.

The RSSI signal strength and distance conversion formula is as follows [10]:

\[ d = 10 \times \frac{\left( \text{abs}(\text{RSSI}) - A \right)}{10^{\text{n}}} \]  

(1)

where, \( d \) is the calculated distance value (unit: m), \( \text{RSSI} \) is the received Bluetooth signal strength, \( \text{ABS}() \) is the absolute value function, \( a \) is the signal strength when the distance between the transmitting device and the receiving device is 1m, and \( n \) is the environmental attenuation factor (table 1).

| Environment  | n  |
|--------------|----|
| Outdoor      |    |
| Open Space   | 2  |
| Covered Space| 2.7-5 |
| Indoor       |    |
| Open Space   | 1.6-1.8 |
| Covered Space| 4-6 |

In this paper, a Bluetooth warning method is designed based on the RSSI value of Bluetooth device and the distance value calculated by equation (1). The method proposed in this paper is mainly used in outdoor space, where the value of \( n \) is between 2 and 5.

3. Bluetooth Low Power Warning Method
This paper presents a low-power Bluetooth warning method, which keeps the low-power Bluetooth device within the safe distance range designed by itself. By comparing the signal strength indication
value sent by the Bluetooth device and the distance between the two devices with the preset signal strength indication value and the preset distance value, the device can be warned in advance that the device is about to be disconnected, an alarm is given, and prevention is made in advance. The Bluetooth device is disconnected and cannot receive the signal. Among them, RSSI value is greatly affected by the external environment, so this paper adds the comparison of distance value.

First of all, preset an RSSI value, distance value D and interval time T. the Bluetooth device sends the RSSI value of the Bluetooth signal to the intelligent terminal through the preset interval time and calculates the distance value between the Bluetooth device and the Bluetooth device according to the RSSI signal strength and distance conversion formula. When the received RSSI value is less than the preset value and the distance between the devices exceeds any of the preset values, the Bluetooth setting Both the standby and the intelligent terminal will give an alarm at the same time to remind the two sides wearing the intelligent terminal and the Bluetooth device that the distance between the two sides has exceeded the safety value.

4. Working Steps and Advantages of Bluetooth Warning Method

4.1. Working Steps and Flow of Bluetooth Warning Method

The detailed steps of this method are as follows:

S1: the intelligent terminal receives the RSSI value of the Bluetooth signal strength sent by the Bluetooth device;

S2: according to the RSSI value of the signal strength indication of the Bluetooth device received by the intelligent terminal, the intelligent terminal calculates the distance between the Bluetooth device sending the Bluetooth signal and it. The distance calculation formula is as follows

\[ d = 10^\left(\frac{abs(RSSI) - A}{10^n}\right) \] (2)

S3: compare the received Bluetooth signal strength RSSI with the preset Bluetooth signal strength value, and compare the calculated distance between the two devices with the preset distance value;

S4: repeat the S1-S3 every predetermined time until the Bluetooth signal strength received by the intelligent terminal is greater than the preset signal alarm strength value or the calculated distance between the two devices is greater than the preset value, the Bluetooth device and the intelligent terminal generate the alarm information and send out the alarm at the same time.

The following figure 1 is the workflow between the intelligent terminal and Bluetooth device:

**Figure 1.** Workflow between intelligent terminal and Bluetooth device.
5. Conclusion
In this paper, a Bluetooth low energy warning method is proposed. The distance between the two devices is calculated by the signal strength RSSI value received by the intelligent terminal. By comparing the preset RSSI value with the received RSSI value, there are also the preset distance value and the calculated distance value of the two devices. When the received RSSI value is less than the preset value and the distance between the devices exceeds any of the preset values, blue both the tooth device and the intelligent terminal will give an alarm at the same time to remind the two sides of wearing the intelligent terminal and the Bluetooth device that the distance between the two sides has exceeded the safety value. The Bluetooth low energy warning method proposed in this paper has the characteristics of low cost, small power consumption, controllable safety range, and has practicability and popularization value.

References
[1] Zhou B, Chen X X and Hu X Y 2014 A Bluetooth low energy approach for monitoring electrocardiography and respiration IEEE International Conference on E-health Networking pp 130-134.
[2] Iqbal Z, Luo D, Henry P, et al. 2017 Accurate real time localization tracking in a clinical environment using Bluetooth low energy and deep learning Plos One 1-13.
[3] Zhang Z F and Shen F T 2020 Application of wireless communication technology in smart grid Telecom Power Technology 37 (2) 197-198.
[4] Jeon W S, Dwijaksara M H and Jeong D G 2017 Performance analysis of neighbor discovery process in Bluetooth low-energy networks IEEE Transactions on Vehicular Technology 66 (2) 1865-1871.
[5] Liu Z Y, Hou M X, Fang W W, et al. 2018 Research on indoor positioning method based on Bluetooth low energy Journal of CAEIT 13 (5) 618-624.
[6] Zhong C 2017 Design on wearable smart bracelet based on single chip technology Microprocessors 3 (6) 75-78.
[7] Ma X P, Cai J H, Yin Y W, et al. 2016 Design and implementation of smart band system Computer Knowledge and Technology 12 (36) 98-102.
[8] Jeon W S and Jeong D G 2017 Enhanced channel access for connection state of Bluetooth low energy networks IEEE Transactions on Vehicular Technology 66 (9) 8469-8481.
[9] Wang L, Liu W Q, Huang G W, et al. 2019 Application of RSSI ranging in robust algorithm for indoor positioning using Bluetooth Navigation Positioning & Timing 6 (3) 82-87.
[10] Peng H, Peng M, An N, et al. 2019 Bayesian region discriminant location algorithm based on Bluetooth Computer Engineering 45 (3) 125-131.
[11] Luo H, Zhang Y, Zou Y M, et al. 2017 Research on Bluetooth location model optimization in complex indoor environment Computer Measurement & Control 25 (11) 244-247.