Preliminary Study for Improving Accuracy of the Indoor Positioning Method Using Compass and Walking Speed

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Abstract. Indoor positioning systems have already been introduced in commercial facilities. Since, the signals transmitted from GPS satellites do not penetrate inside buildings, Wifi, Zigbee and Bluetooth are used for indoor position estimation. In this work, we only focus on the use of Bluetooth due to its advantages such as low power consumption, wide signal range and inexpensive. However, the accuracy of positioning is not sufficient in current technologies. Therefore, this paper proposes an indoor positioning method for improving accuracy, using compass and walking speed with an extended Kalman filter. Preliminary experimental results improves accuracy up to 21.2%.

Keywords: Indoor positioning · BLE · Fingerprint · Extended Kalman filter

1 Introduction

GPS is widely used as a method of determining location. Location information is often needed in smartphones where many applications require GPS to function [1, 15, 18]. However, the signals transmitted from GPS satellites do not penetrate inside the buildings [2, 11, 14], tunnels and underground subway stations [17]. Hence, we propose an indoor positioning system using Bluetooth and Wifi. Many researches use RSSI (Received Signal Strength Indicator) level of Wifi access points or BLE tags for estimating indoor position [19, 20, 23, 37–39]. Wifi is commonly used for indoor positioning technology but the signal has to be strong and cover a relatively wide area. However, Wifi equipment requires an external power source, more setup costs and expenditure. Bluetooth Low Energy (BLE) [4, 13, 16] is one of the latest technologies. Called BLE beacons (or iBeacons), they are inexpensive, small, have a long battery life and do not require an external energy source [26]. In this work, Bluetooth technology is used for indoor position estimation [29, 30] due to its low cost and low power. Moreover, there are many researches on indoor localization using inertial sensors and geomagnetic sensors using smartphones. This method can estimate position [12, 21, 22] and detect the direction in which the person is walking. Nevertheless, the positioning accuracy is not sufficient in this method [3, 6, 7]. In this paper, we report a preliminary study of position estimation methods using RSSI [5, 8–10] combined with smartphone sensors (inertia and geomagnetic), which can provide location information and walking

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data of people or objects inside a building with possibly better accuracy and better cost performance. In this article, Sect. 2 describes our proposed method, Sect. 3 explains the experiment in detail, Sect. 4 summarizes the experimental results, we discuss future steps in Sect. 5 and finally, we conclude our report in Sect. 6.

2 Proposed Method

There are various indoor positioning methods. In a study written by Shiu [1], Wifi RSSI data was used with a Multi-Layer Perceptron (MLP) [33, 34] based classifier to estimate the position. Moreover, research on location estimation using a smartphone was conducted by Rui [2]. He proposed a method that used Kalman filter [25, 28, 32] for sensor fusion in a smartphone. Therefore, the method proposed in this work is composed of both, position estimation using MLP [24, 27] and extended Kalman filter that improves accuracy. The proposed system is shown in Fig. 1.

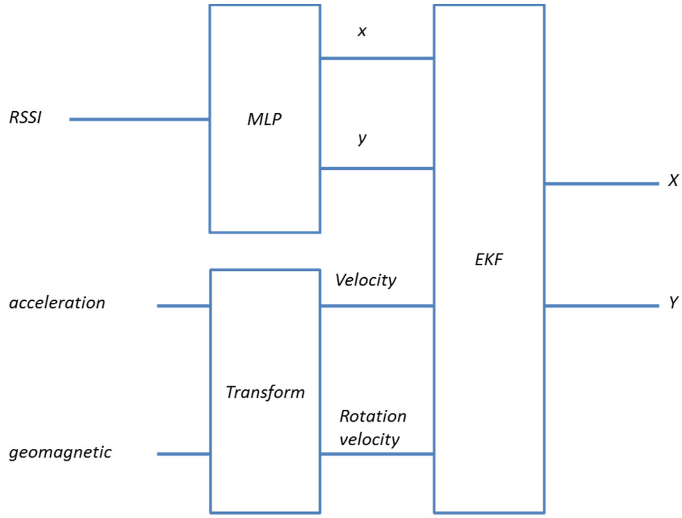

Fig. 1. Block diagram of the proposed system

3 Methods

First, we made experiments of acquiring training data for using finger-prints. This experiment was carried out using a smartphone. Figure 2 shows the environment of the experiment, which was a space of 4 × 4 m. Four BLE beacons have been placed in this space.

We measured RSSI value of 16 points and obtained 20 data at each point. After that, we estimated the position using the MLP algorithm. We then calculated variance of MLP output data, acceleration sensor and geometric sensor. Below, the extended

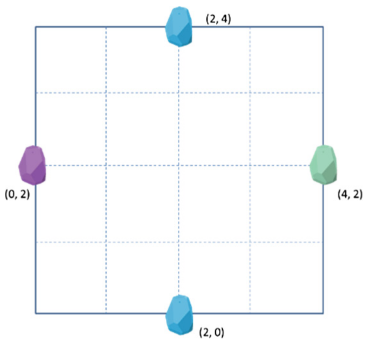

Fig. 2. Experiment environment

Kalman [26, 31] filter algorithm can be seen. Extended Kalman filter expressed in Eq. (1) as the observation update and Eq. (2) as the temporal update.

Step1

$$\begin{gathered}\hat{x}^{-}(k) = f(\hat{x}(k-1)) \\ P^{-}(k) = A(k)P(k-1)A^{T}(k) + \sigma_{v}^{2}(k)bb^{T} \\ g(k) = \frac{P^{-}(k)c(k)}{c^{T}(k)P^{-}(k)c(k) + \sigma_{w}^{2}}\end{gathered} \tag{1}$$

Step2

$$\begin{gathered}\hat{x}(k) = \hat{x}^{-}(k) + g(k)\{y(k) - h(\hat{x}^{-}(k))\} \\ P(k) = \{I - g(k)c^{T}(k)\}P^{-}(k)\end{gathered} \tag{2}$$

4 Results

The experimental results are shown in Table 1. Method number 1 is only the fingerprint method. Method number 2 is the proposed method. The average error shows that error decreases with method 2 by 21.2% in comparison to method 1.

Table 1. Estimation errors [m]

Method	MAX error	Min error	Average error
1	3.61	1.00	2.21
2	2.92	0.51	1.75

5 Discussion

These results show that the proposed method is more effective at reducing the error. However, the accuracy obtained in the proposed method is not sufficient And further work is required to improve accuracy. This study did not test the other estimate method, therefore more research is needed.

6 Conclusions

In this paper, we conducted a preliminary study for improving the accuracy of an indoor positioning method using compass and walking detect. We tested the combination of MLP, velocity and rotational velocity using extended Kalman filter. We evaluated the overall fingerprint matching performance between the proposed method and conventional methods.

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