지구자기장과 WiFi 융합기반 실내측위 정확도향상 기법

Fusing geomagnetic field data with Wi-Fi for increasing indoor localization accuracy

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Abstract

Geomagnetic field data-based indoor localization has gained a wide attraction recently due to its pervasiveness and wide proliferation of smartphones. However, the similarity of magnetic field data in large complex buildings degrades its performance. Additionally, the heterogeneity of smartphones cripples its localization accuracy as well. This research fuses the geomagnetic field data with Wi-Fi data to improve its accuracy and alleviates the impact of device heterogeneity.

Ⅰ. Introduction

Indoor positioning and localization is a rapidly expanding research field owing to the spread of smartphones and the inception of location-based services. Consequently, a large range of indoor localization techniques like Bluetooth [1], Wi-Fi [2], and pedestrian dead reckoning has been proposed during the last few years. However, the installation of sensors and beacons for their operation makes them infrastructure dependent and expensive. The geomagnetic field data is pervasive and does not require additional hardware for positioning and localization. Smartphones contain an embedded magnetic sensor that can be used for positioning. However, large and complex indoor spaces have similar data intensity at various distant locations that affect the localization accuracy of such systems. Moreover, the heterogeneity of smartphone embedded geomagnetic sensor causes data variability and degrades the localization performance of the geomagnetic field based positioning systems. This study proposes the use of Wi-Fi data with the geomagnetic field data to overcome these limitations.

Ⅱ. Proposed Approach

This study uses data from multiple smartphone sensors for localization. The proposed approach comprises of two phases: offline phase and an online phase. During the offline phase, the Wi-Fi and the magnetic field data are collected at ground truth positions to make the fingerprint databases. On the other hand, the online phase involves using the accelerometer, gyroscope, Wi-Fi, and the magnetic field data for localization. Figure 1 shows the proposed methodology for indoor localization.

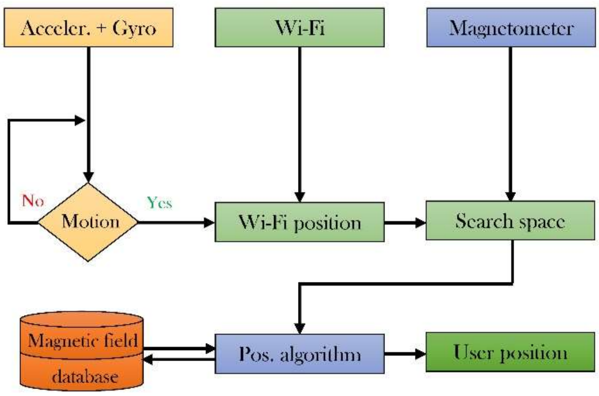

Figure 1. The architecture of the proposed approach

The data from the accelerometer and gyroscope is utilized to detect motion using the threshold method proposed in [3]. If the user is moving, Wi-Fi data is used to estimate a coarse position of the user. For this purpose, K nearest neighbor (KNN) is used with a Wi-Fi fingerprint database. The average error for Wi-Fi indoor localization is approximately 5~6 m. Wi-Fi position is used to restrict the search space for the geomagnetic field database. Location estimation with the geomagnetic field data is based on Euclidean distance:

$$d = \sqrt{(Mx_{db} - Mx_u)^2 + (My_{db} - My_u)^2 + (Mz_{db} - Mz_u)^2}$$

Where *x*, *y*, and *z* are the magnetic field values while *db* and *u* show the databased and user collected values, respectively. The KNN algorithm is used for locating the user and *k* is set to 5 for the current study.

Ⅲ. Results

Experiments are performed in a university building of 92×34 m^2 area. Samsung Galaxy S8 is used for experiments. The cumulative distributive function (CDF) graph of localization is shown in Figure 2. Results show that using either the Wi-Fi or geomagnetic alone yields in large localization error. Although 50% error is approximately 5 m for both, yet the maximum error is 24.10 m and 33.06 m for Wi-Fi and geomagnetic field data, respectively. Similarly, error at 75% is 13.39 and 9.44 m for Wi-Fi and geomagnetic field data, respectively. This error is high for an indoor environment where the precise location of the user is desirable.

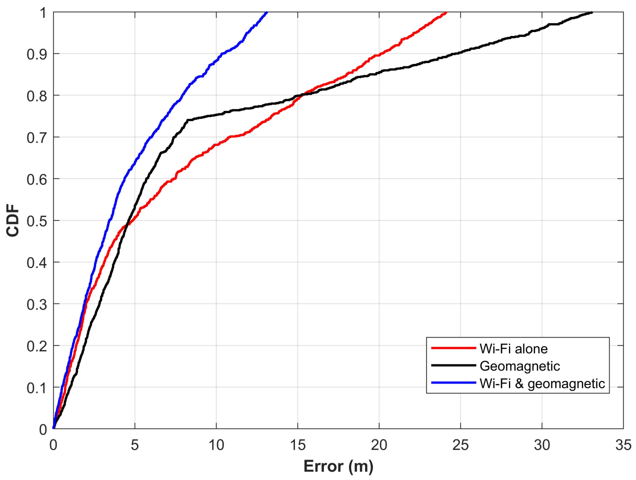

Figure 2. The CDF graph for localization results.

Results given in Figure 2 for the fusion of W-Fi and geomagnetic field data show superior performance. Experiment results demonstrate that the use of Wi-Fi data to restrict the search space improves the localization performance of the geomagnetic field-based indoor positioning. Mean, 50%, 75% the maximum error is reduced substantially. With the fusion strategy, the user can be located within 5 m for 65% and within 10 m for 90%. Additionally, the maximum error is reduced to 13.11 m. Results approve the effectiveness of the fusion of the Wi-Fi and geomagnetic field data to improve the localization accuracy. Detailed statistics about the localization performance are given in Table 1.

Table 1. Statistics for localization accuracy

Technique	Error			
	Mean	50%	75%	Max.
Wi-Fi	7.79	4.86	13.39	24.10
Geomagnetic	8.29	4.61	9.44	33.06
Wi-Fi & geomagnetic	4.51	3.42	6.94	13.11

Ⅲ. Conclusion

Geomagnetic field-based indoor positioning and localization systems suffer performance degradation due to large and complex indoor structures and smartphone heterogeneity. This study investigates the fusion of the Wi-Fi and geomagnetic field data to improve indoor localization accuracy. Wi-Fi data is used to estimate a coarse location to restrict the search space for the geomagnetic field database. Results demonstrate that the fusion show superior localization performance than that of using Wi-Fi and geomagnetic field data alone. Mean, 50%, 75%, and the maximum error are reduced when Wi-Fi and geomagnetic field data are fused.

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