Precise Indoor Localization Fusion System

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***Abstract*—The proposed localization system exploits Wi-Fi and geomagnetic fingerprintings aided by Inertial Measurement Unit (IMU) and Computer Vision (CV) techniques. Basically, the system uses only the sensors and modules in the personal mobile phone and no extra equipments are required. As Wi-Fi fingerprinting and geomagnetic fingerprinting are complimentary, they together help improve the performance of indoor localization. However, the precision of such fingerprint-based approach is still heavily influenced by surrounding environment (metal/magnetic materials, active high-power devices, etc.). To overcome the shortages, the proposed system adopts a Bag of Visual Words (BOVW) model to compensate for the weakness of Wi-Fi and geomagnetic fingerprintings. Besides that, this work utilizes the state-of-the-art orientation prediction and step detection of IMU module, and adopts a data fusion framework to fuse Wi-Fi and geomagnetic fingerprints, BOVW model, and inertial data to improve the precision of indoor localization.**

***Index Terms*—Wi-Fi and GeoMagnetic Fingerprints; BOVW; IMU; Data Fusion Framework**

I. Introduction

Precise indoor localization greatly facilitate our daily life. For instance, it can help us to search for points of interest in a large shopping mall and navigate us to a specific room in an unfamiliar building. The satellite-based positioning systems, such as GPS, are generally unavailable or inaccurate in indoor scenarios due to the attenuation of signals caused by environmental constrains. Therefore, recent years have witnessed growing interests in indoor localization and navigation system. Wireless access point or Bluetooth beacon based approaches are expected to ease indoor localization. However, the reflection, diffraction and scattering effects involved in these technologies considerably decrease localization accuracy and often result in a very inefficient infrastructure for indoor localization. In recent research we have found that Wi-Fi and geomagnetism fingerprintings are complimentary. Besides, mobile phones are equipped with cameras and increasingly fast processors which make it possible to handle real-time matching for BOVW. Hence in this work we propose to exploit the fingerprintings based on Wi-Fi, geomagnetism, and BOVW, and fuse them with inertial data on mobile phones. The fusion framework is expected to produce a more precise indoor localization algorithm.

II. SYSTEM STRUCTURE

The geomagnetic-fingerprint-based indoor localization has been extensively studied and proved to be an attractive method to locate an unknown target in indoor environments. However, it still needs additional measurements to compensate the insufficient accuracy which may result from magnetic materials and active high-power devices around. Another weakness is that the geomagnetic fingerprints may not be unique in a large indoor space. As a result, some other new techniques or extra information are required to improve the localization accuracy. To achieve it, the BOVW model is applied where Wi-Fi and geomagnetic fingerprints suffer severe distortion since certain points of an indoor environment remain comparatively time-invariant. In a word, the proposed algorithm exploits the readings of various sensors for steps and orientation detection to develop an IMU-based navigation system. The system also utilizes the visual data of mobile phone camera to develop a BOVW-based algorithm and integrate it with Wi-Fi and geomagnetic fingerprinting to achieve high precision, and we call it a Precise Indoor Localization Fusion System (PILFS). The framework of the PILFS system is shown in Fig. 1.

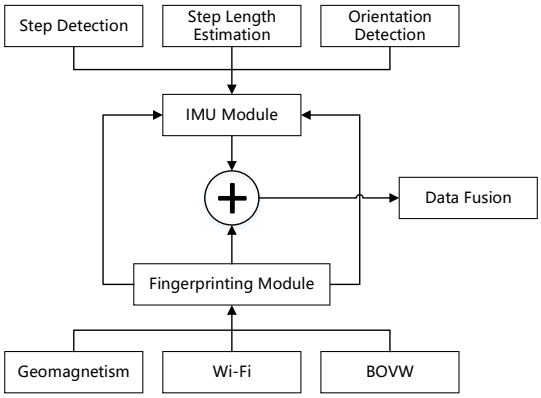

Fig. 1. Framework for the proposed PILFS system

A. Fingerprinting Module

In the PILFS system, a fingerprinting module is designed to collect the visual data from mobile phone camera, together with the Wi-Fi and geomagnetic field strength on every reference points to develop an off-line fused fingerprinting database, which is searched by end users for matching during the on-line localization period.

B. IMU Module

In the PILFS system, an IMU module is proposed to aid the fingerprinting module. Specifically, to recover the true

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step signal, the step detection algorithm applies both time and amplitude thresholds of accelerometer for distinguishing that from pseudo signals. To get rid of the drift and noise of predicted orientation, the proposed system leverages the magnetometer and accelerometer for long-time orientation detecting, and the gyroscope for the orientation changes sensing in short time intervals. To have a better estimation of the step length, the proposed system adopts motion matching and individual customized strategy.

C. Data Fusion Framework

In the system, the fingerprinting module helps correct the drift of the IMU module, and in the meanwhile, the IMU module helps smooth the variation of the fingerprinting module. In other words, this work fuses all the data, i.e., Wi-Fi and geomagnetic fingerprints, visual and inertial data, for final optimal location estimation.

III. DEPLOYMENT REQUIREMENTS

The system uses geomagnetism, Wi-Fi, BOVW, and IMU data to achieve precise indoor localization. Since all data used are available in modern mobile phones, no extra equipment or infrastructure is required in deployment.

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