Precise Indoor Localization Platform Based on WiFi-GeoMagnetic Fingerprinting and Aided IMU

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***Abstract*—The proposed system exploits Wi-Fi and GeoMagnetic fingerprintings aided by Inertial Measurement Unit (IMU). Basically, the system only consists of the off-the-self Wi-Fi Access Points (APs) and low-cost IMU, while no extra equipment is required. Since the accuracy of Wi-Fi fingerprinting heavily depends on the number of APs deployments, spatial differentiability, and the fluctuation of Received Signal Strength Indictor (RSSI) caused by multipath, the performance of Wi-Fi fingerprinting based indoor localization system frequently varies with the changes of the time and locations. To overcome this shortage, the proposed system takes advantage of the stable geomagnetic fingerprinting to compensate for the weakness of Wi-Fi fingerprint based indoor localization algorithm. Besides that, this work utilizes the state-of-the-art orientation prediction and step detection of IMU module, and adopts a Kalman filter framework to fuse both Wi-Fi and geomagnetic fingerprintings, and inertial data to improve the precision of indoor localization.**

Keywords—Wi-Fi Fingerprinting; GeoMagnetic Fingerprinting; IMU; Kalman Filter Framework

I. INTRODUCTION

Indoor localization and navigation system has attracted significant research interest. It has acted as a promising alternative method to derive the location of mobile unit, since 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. Precise indoor localization can greatly facilitate our daily life. For example, it can help us to search for points of interest in a large shopping mall or an airport, navigate us to a specific room in an unfamiliar building and guide us to find a car in a parking lot. Considering that Wi-Fi networks have been deployed in most buildings and mobile units are equipped with lots of sensors and are ubiquitous nowadays, in this work we propose to exploit the Wi-Fi and geomagnetic fingerprinting algorithm fused with IMU data, which are expected to produce a more precise indoor localization algorithm.

II. SYSTEM STRUCTURE

The RSSI based indoor localization algorithm is an easy and well-known scheme to locate an unknown target in indoor environments; it needs additional measurements to compensate the insufficient accuracy which may result from the multipath caused by reflection, diffraction and scattering effects. To improve the location accuracy, some other new techniques or extra information are required to be included. Fortunately, nowadays smartphones are usually equipped with many sensors, e.g. accelerometer, magnetometer, gyroscope, etc. The information collected by these sensors will help us to improve location accuracy. Based on that, the proposed algorithm exploits the readings of them for steps and orientation detection to develop an Inertial Measurement Unit based navigation system. Different from Wi-Fi fingerprinting, geomagnetic fingerprinting is quite stable over time, but it may not be unique in large indoor environment. In this work, geomagnetic fingerprinting is used as a complementation of Wi-Fi fingerprinting.

A. WiFi-GeoMagnetic fingerprinting

As a fingerprinting approach, the proposed system needs to collect the Wi-Fi RSSI of different APs and the geomagnetic field strength on every reference points to develop an off-line fingerprinting database, which is searched by end users for matching during the on-line localization period.

B. IMU based localization algorithm

To recover the true 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,

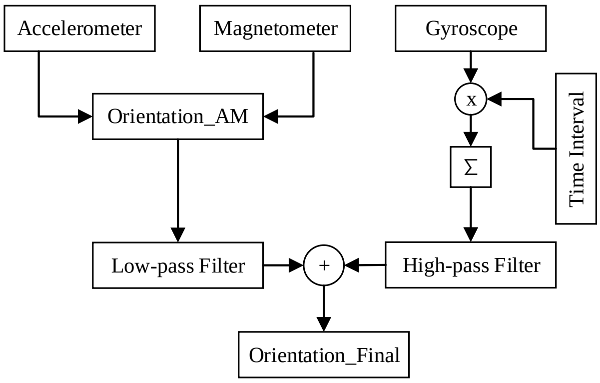

Fig. 1. Sensors Fused for Orientation Prediction

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, see Fig. 1.

To have a better estimation of the step length, the proposed system adopts motion matching and individual customized strategy.

C. Kalman filter framework

This work formulates the sensor fusion problem in a linear perspective, then all the data goes through the Kalman filter. This kind of technique has been widely used in the literature for final optimal location estimation. Moreover, the fingerprinting based approach helps correct the drift of the IMU based localization method, and in the meanwhile, the IMU based method will be useful in smoothing the variation in the fingerprinting based approach.

III. Deployment Requirements

While the system provides precise indoor localization by incorporating Wi-Fi and geomagnetic fingerprintings, IMU, and Kalman filtering, it needs only the Wi-Fi network in the test buildings, and no extra equipment or infrastructure is required.

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