Inertial Sensing Approach for Indoor Localization

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***Abstract*—The proposed method exploits Pedestrian Dead Reckoning (PDR). It only uses the sensors and modules in the personal mobile phone and no extra equipments are required. While fingerprinting approaches such as Wi-Fi or geomagnetic fingerprintings help improve the performance of indoor localization, the precision of such fingerprint-based systems is still heavily influenced by surrounding environment (metal/magnetic materials, active high-power devices, etc.). To overcome the shortages, the proposed system uses mobile's inertial sensors to track user location. Specifically, this work utilizes the state-of-the-art heading estimation and step detection of Inertial Measurement Unit (IMU), and adopts a data fusion algorithm to fuse inertial data to improve the precision of indoor localization.**

***Index Terms*—PDR; IMU; Data Fusion**

I. Introduction

Precise indoor localization is an attractive technology to improve our daily life. For example, it can help navigate us to where we want to get in shopping malls or hospitals or guide us to find a car in a parking lot. 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. Hence indoor localization and navigation system has acted as a promising alternative method to derive the location of mobile unit and attracted significant research interest. In recent years wireless access point or geomagnetism based fingerprinting approaches are expected to ease indoor localization. However, the accuracy of fingerprinting based on wireless access point heavily depends on the number of infrastructures deployments, spatial differentiability, and the fluctuation of Received Signal Strength Indictor (RSSI) caused by multipath effect. The geomagnetic fingerprinting is also heavily influenced by surrounding environment (metal/magnetic materials, active high-power devices, etc.). Considering that modern mobile phones are equipped with lots of sensors and increasingly fast processors which make it possible to handle real-time localization without any other auxiliary equipments, in this work we propose to exploit inertial data from the smart phone and fuse them to produce a more precise PDR based indoor localization.

II. SYSTEM STRUCTURE

The fingerprint-based indoor localization has been extensively studied and proved to be an attractive method to locate an unknown target in indoor environments. However, the performance of such indoor localization system may frequently vary with the changes of the time and locations. It still needs additional measurements to compensate the insufficient accuracy which may result from reflection, diffraction, scattering effects and surrounding environment, which makes it unstable and hard to extensively promote. Nowadays smart phones are usually equipped with many sensors and the information collected by these sensors enable us to detect and estimate steps and heading to track user location. Hence the proposed algorithm exploits the readings of them and fuse the data to develop a PDR based indoor localization. Since sensors in smart phones can always provide the needed data even in flight mode, the system can achieve a better localization stability and usability. It can be applied to any other localization algorithm to compensate for their weaknesses, and we call it an Inertial Sensing Indoor Fusion Tracking System (ISIFTS). The framework of the ISIFTS is shown in Fig. 1.

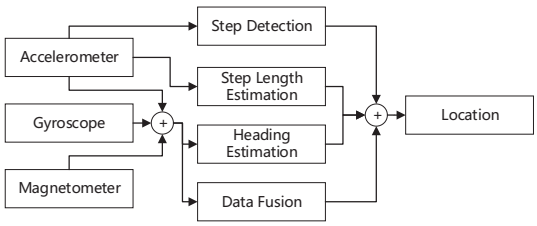

Fig. 1. Framework for the proposed ISIFTS

A. Step Detection

In the ISIFTS, we use data from accelerometer to detect steps. To recover the true step signal, we apply both time and amplitude thresholds of accelerometer for distinguishing that from pseudo signals. The thresholds during the detection are dynamic to make the system more stable and accurate.

B. Step-Length Estimation

Methods based on fixed step-length suffer from accumulative errors in step-length estimation. The ISIFTS uses dynamic step-length estimation to mitigate the errors. To have a better performance, the system also adopts motion matching and individual customized strategy.

C. Heading Estimation

To get rid of the drift and noise in the heading estimation, the ISIFTS leverages the magnetometer and accelerometer for

This work was supported in part by Naviguy Inc. and Tongji University. The correspondence author is Erwu Liu (erwu.liu@ieee.org).

long-time heading detecting, and the gyroscope for the heading changes sensing in short time intervals.

D. Data Fusion

Since the PDR system would encounter severe performance degradation over a long period of time, for the ISIFTS method we develop a quaternion-based fusion technique to integrate gyroscope, accelerometer, and magnetometer for the calculation of attitude angles to effectively improve the system stability and accuracy.

III. DEPLOYMENT REQUIREMENTS

The system uses inertial data to achieve precise indoor localization. Since all data used are available in smart phones, no extra equipment or infrastructure is required in deployment.

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