Particle Filter and Support Vector Machine Based Indoor Localization System

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***Abstract*—In this paper, the localization algorithm based on particle filter and support vector machine is described. The speed and heading of user are calculated by mobile device and transmitted to the server. Accurate algorithm is performed on the server. The system does not require specific initialization or specific hardware deployment. It is a ready system for commercialization.**

I. Introduction

The system is developed as a commercial solution for indoor positioning and indoor navigation. It is implemented based on android system using Wi-Fi wireless network, inertial measurement unit (IMU) and magnetometer. The algorithm takes advantages of all the available sensors on cellphone and leverages particle filter to perform sensor fusion.

II. System structure

The proposed system consists of several mobile devices, a Wi-Fi network with a few routers and a server (computer). Service provider constructs a radio map by collecting data from different reference points. Radio map serves as the training set of fingerprinting algorithms. Pattern recognition algorithms are used for the construction of prediction model. The model is stored on the server for on-line fingerprinting prediction. An android application is developed for gathering the speed and heading of users. All the positioning algorithms are performed on the server.

As the whole system utilizes smart phones as mobile clients and existing Wi-Fi network in the buildings as infrastructure, no extra hardware deployment is required.

III. Localization Algorithm

A. Wi-Fi Based Fingerprinting Approach

The mobile device is employed to collect the Wi-Fi received signal strength indicator (RSSI) of different access points on the reference points (RPs). The access points (APs) are served as beacons. The data is sent to a server, where the RSSI values are built into vectors acting as a prior knowledge. The radio map is formed after gathering the RSSI vectors of all the desired areas and saved into database. In our approach, Support Vector Machine (SVM)[1] is used to classify the incoming RSSI vector into known locations.

B. Pedestrian Dead Reckoning

Fingerprinting method can get error distance for less than three meters. In order to achieve a higher accuracy, dead-reckoning has been combined with fingerprinting method. It requires the current speed and heading of user and integrates the data based on the starting point. The speed on heading can be calculated by the data from Inertial Measurement Unit (IMU) on the mobile devices. IMU is normally consist of accelerometer and gyroscope. For human speed estimation, step sensor implemented by accelerometer and gyroscope offers relatively good estimations of step counts and step length. Users heading is calculated from gyroscope and compass data.

C. Particle Filter

All the data including the results of Wi-Fi fingerprinting, PDR and magnetic field goes to particle filter for final optimal location estimation. Particle filter is based on Sequential Monte Carlo methods. As a popular object tracking algorithm, the idea of particle filter is to generate a set of particles for posterior distribution estimation. The major advantage of particle filter is that it could deal with non-linear problems. In indoor positioning, the noise is normally complicated. It is preferred to choose particle filter because it could handle different types of noise[2]. Moreover, it is easy to integrate the map information. Map matching method is useful to calibrate the trajectory of pedestrian which prevent the trajectory passing from unreachable areas.

References

[1] C.-W. Hsu, C.-C. Chang, C.-J. Lin *et al.*, "A practical guide to support vector classification," 2003.

[2] B.-F. Wu and C.-L. Jen, "Particle-filter-based radio localization for mobile robots in the environments with low-density wlan aps," *Industrial Electronics, IEEE Transactions on*, vol. 61, no. 12, pp. 6860–6870, 2014.